FOREST LEVEL BENEFITS TO COMMERCIAL THINNING AND FERTILIZATION

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Forest Practices Branch
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Attention: Mel Scott
Silvicultural Systems Forester

Dear Sirs,

Reference: *Forest Level Benefits to Commercial Thinning and Fertilization*

Please accept this report for the above mentioned project.

It has been our pleasure working with you.

Yours truly,
TIMBERLINE FOREST INVENTORY CONSULTANTS LTD.

David M. Carson, R.P.F.
Forester, Resource Analysis

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EXECUTIVE SUMMARY

The Timber Supply Review process recently completed in British Columbia has identified some significant harvest reductions in specific timber supply areas (TSAs). Although incremental silviculture was generally not incorporated into these analyses, commercial thinning and fertilization are viewed as treatments that have the potential to mitigate declining harvests. The potential may exist given particular forest age structures, management history and stand conditions.

A study was done to identify forest level benefits that may accrue from commercial thinning and fertilization. A sensitivity approach was taken with sets of parallel analyses based on various levels of stand response to treatments. The focus was not on stand yield modelling. Presented are a range of forest level analyses which reflect a range of stand responses to commercial thinning and fertilization.

A limited review of potential stand level responses to commercial thinning and fertilization was undertaken. Based on general findings of the review, a reasonable range of individual or combined growth response to the treatments was identified. Analyses were undertaken using yields representing a range of increases from zero to 35 % in cumulative merchantable volume at final harvest.

Also presented is a description of the mitigating effects that fertilization and commercial thinning may have on currently declining harvests by means of improved green-up rates, earlier availability of timber and partial timber removal in sensitive zones.

Timber Supply Review documentation for all TSAs in the province was reviewed for forest structures, market opportunities and management regimes that hold promise for harvest level improvements due to commercial thinning and fertilization treatments. Two TSA test cases were chosen for their potential to demonstrate forest level benefits to commercial thinning and fertilization. Timber Supply Area analyses involve the establishment of a base case for comparison, and implementation of commercial thinning and fertilization to evaluate changes in sustainable harvest schedules. Treatments were modelled in two ways. First, post treatment yields were represented by subjectively modified managed stand yields which reflect stand level response expectations based on the literature. Secondly, the MoF model Tree and Stand Simulator (TASS) was used to build treatment yields for comparison purposes.

Arrowsmith TSA

Results indicate that commercial thinning and fertilization may be used in the Arrowsmith TSA to counteract a decline in harvest levels. Fertilization as a stand alone treatment demonstrates some mid term gains (one or two decades only with impacts ranging between two and 13 %) but most impact is in the long term–two

percent, five percent and 13 % for low, moderate and high stand level response respectively. Early fertilization demonstrated significant improvements in the short term but had a long term effect only when a 50 % reduced green-up period was assumed. Commercial thinning alone demonstrated little long term impact but very strong short term impacts, independent of stand level response assumptions. Commercial thinning and fertilization together provides forest level opportunities in both the short and long term based on the contribution of each of the two treatments. Demonstrated short term benefits range from eight to 22 % per decade. Long term benefits are in the one to 14 % range depending on the yield response assumption.

Kootenay Lake TSA

In the Kootenay Lake TSA we found significant harvest schedule improvements through various applications of commercial thinning and fertilization. Commercial thinning as a stand alone treatment demonstrated between five and 11 % increases in the short term and no or little benefit in the mid and long term. Fertilization only demonstrated six percent increases in harvest level (12 % in one decade) independent of stand response assumption. Only moderate and high response assumptions demonstrated any long term gains (six and 12 % respectively). A combined commercial thinning and fertilization regime resulted in 11 % short term gains and increases in harvest levels in the long term ranging from three to eight percent. Short term benefits reflect the degree to which forest cover constraints are limiting short term harvests. The availability of older existing stands allows volume increases in managed stands to be translated to short term harvest increases.

This report provides results from two timber supply areas. These results can not be extrapolated to other TSAs or rolled-up to provincial estimates. One can however, look for similar forest conditions in other TSAs and draw inferences. The methodology demonstrated here can be used to evaluate possibilities in other TSAs.

Although forest level benefits can be demonstrated at all levels of stand yield response, the magnitude of benefits is sensitive to the stand yields. There remains a need for further investigation of growth and yield under commercial thinning and fertilization management regimes.

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1.0 INTRODUCTION

Application of commercial thinning and fertilization on a production basis in B.C. is expected to increase due to changes in legislation and policy such as the Forest Practices Code of B.C. Act and Forest Renewal BC (Simons Reid Collins, 1996).

The Timber Supply Review (TSR) process in British Columbia has identified significant timber supply reductions in specific timber supply areas (TSAs). These reductions result from a combination of existing forest structure, forest dynamics, harvestable land base reductions and changes in forest practices. The timing of reductions varies substantially across TSAs, as do the opportunities to mitigate these impacts by altering stand level silviculture tactics. Specifically, commercial thinning and fertilization are being viewed as treatments that have this potential in the context of particular forest age structure, and if applied at the appropriate time and in the appropriate stand conditions.

Timberline Forest Inventory Consultants has been retained by the Forest Practices Branch of the B.C. Ministry of Forests to identify strategic opportunities for application of commercial thinning and fertilization. This is accomplished by demonstrating possible forest level benefits associated with these two stand treatments.

This report reviews the stand level responses to these commercial thinning and fertilizing treatments, possible forest level implications of these treatments, and the potential application of these treatments across the province. It documents TSA test cases to enumerate the potential forest level benefits. This study is not one of economic efficiency and makes no assumptions as to future market conditions or returns to investments in commercial thinning and fertilization.

2.0 STAND LEVEL IMPACTS

This section provides a description of the expected stand level effects of fertilization and commercial thinning based on current knowledge and understanding. Quantification of response to treatment is a necessary input to the forest level analyses which will follow. In preparation of these stand level responses, a limited review of the body of pertinent published literature was undertaken and several recognized experts were consulted. Stone (1993, 1996) provides valuable reviews of pertinent literature and summaries of commercial thinning results.

2.1 Commercial Thinning

MoF policy describes commercial thinning as a partial cut in immature stands, where trees have reached merchantable size, and timber removed in the thinning is sold. It goes on to set the following guideline: commercial thinning provides an interim harvest while maintaining or redistributing stand growth without reducing the potential of the residual stand.

There is a paucity of established trials on stand level response to commercial thinning in British Columbia. However, commercial thinning is generally believed to achieve one or more of the following stand level objectives: 1) capture natural mortality; 2) concentrate growth in fewer stems; 3) increase the merchantable proportion of a stand; 4) decrease final harvest costs; and 5) increase timber value. In terms of total volume production, commercial thinning involves a trade-off between capturing natural mortality and decreasing growing stock thereby under-utilizing the site. For this reason frequent light thinnings have been shown to maximize total volume production (Nawitka, 1987). However, these are hard to justify due to harvesting economics.

Commercial thinning on the coast has been shown to marginally increase cumulative total and merchantable volumes for both coastal Douglas-fir and western hemlock (Omule, 1988), presumably capturing mortality. Height growth was not affected. Quadratic mean diameters increase as a result of the removal of small stems, but crop tree quadratic mean diameter was largely unchanged. Douglas-fir was more responsive than hemlock.

MacMillan Bloedel reports parallel volume response for thinnings of less than 30 % of volume and involving a ratio of thinned diameter over pre-thinning diameter of less than .8 in coastal stands (Smith, personal communication). A parallel response represents no net increase or decrease in accumulated volume. Heavier cuts resulted in decreasing yields.

Stone (1993) provides a review and summarization of the literature on thinning of Douglas-fir. General conclusions from the literature are that: 1) increases in cumulative merchantable yield will be less than 10 %; 2) thinning can capture most merchantable volume otherwise lost to mortality; and 3) commercial thinning is economically viable on high productivity sites or where rotations beyond economic rotation are used. Simulations

involving stand level growth modelling undertaken by Stone in Douglas-fir also lead to the conclusion that commercial thinning likely only provides a marginal increase in the cumulative merchantable volume available from a stand over a rotation.

Stone (1996) provides a similar report for lodgepole pine with the following conclusions from the literature (not all are reproduced here): 1) gross and total volumes increase with density in young stands but merchantable volumes were higher on thinned plots, particularly with light thinnings; and 2) growth and yield analysis concluded that commercial thinning will provide at best a marginal increase in the net merchantable volume available from a stand over a rotation.

Coastal candidates are Douglas-fir on medium or good sites, with thinning from below (Stone, 1993). Hemlock is targeted but has shown less benefit (Forest Fertilization Guidebook). Interior candidates are lodgepole pine using a low thinning (Stone, 1996).

2.2 Fertilization

Fertilization is a silvicultural treatment that can be effectively used to increase merchantable yield and value of established forests. It can also be used strategically to accelerate the development of specific age classes and timber types. Various studies over the years have provided promising results from fertilization trials (Brix 1992).

This report will consider fertilization in two separate contexts; for increasing harvest volume, and for accelerating height growth.

Increasing Volume

Benefits from fertilization are often maximized when the treatment is in combination with thinning (especially spacing) and research projects usually involve both.

Fertilization treatments raise the productivity of a site and reduce the age at which a stand reaches harvestable size (Nawitka, 1987). In the first years after treatment it is reasonable to expect the combined effects on merchantable volume of spacing and fertilization combined to exceed the sum of the separate treatment effects. Later this "synergistic" effect should diminish (Nawitka, 1987).

The direct effect of a single fertilizer treatment is thought to result in a short term increase in stand growth. In coastal Douglas-fir it appears to last about 12 years. Because fertilization changes stand structure (crown structure, diameter distribution), the subsequent development of a fertilized stand will be different from an untreated stand (Nawitka, 1987).

Increased volume production in the first year post treatment is due to increased photosynthetic efficiency caused by higher foliar nitrogen levels. After that the increase in volume is primarily due to added foliar mass. This is why it is imperative to have room for crown expansion following fertilization and why combined treatment with pre-commercial thinning is advantageous (Province of B.C., 1995).

Preference has been shown for fertilizing thrifty mature stands where results will be felt at harvest time without compounding the treatment cost for a long period of time. Commercially thinned stands are good candidates.

Holger Brix (1992) provides a synthesis of project results of fertilization and thinning effects at Shawnigan Lake. Thinning was shown to decrease the total volume and net volume increments because of the reduction in growing stock, but to increase the merchantable volume and merchantable increments. Fertilization greatly increased total and merchantable volumes within all thinning levels, and responses were still evident 15 years after treatment.

The Shawnigan Lake plots provide evidence of increases in merchantable volume associated with various (non-commercial) thinning and fertilization regimes. Accumulated merchantable volume increases at the 17.5 cm utilization level over a 15 year period range from 65 % for light thinning and fertilization to 215 % for repeated heavy fertilization. Site index of the site was 25.

Brix (1993) reviewed western hemlock growth response to fertilization and reported that response has been inconsistent and even negative. Further study is needed to clarify the unpredictable results and develop site specific guidelines. Growth response has been shown to be positively correlated to fertilizer treatments in association with thinning, the thinning treatment providing room for crown expansion.

MacMillan Bloedel reports gains from application of 225 kg of N per ha in coastal stands of site index 24 to 35 only. Unthinned stands yielded volume increases of four percent at 6 years, thinned stands five percent at 10 years. Gains were transient and disappeared after 6 years unthinned, and 15 years thinned.

Species showing the best response have been Douglas-fir and to a lesser degree western hemlock on the coast, and lodgepole pine and wet belt Douglas-fir in the interior.

On the coast, fertilizing is recommended on the following sites and in this order of priority: poor, medium, good (MoF site classes). Good sites will usually produce a smaller relative impact but a larger absolute positive response and treatment is advisable where there is a moist moisture regime (Province of B.C., 1995).

In the interior, medium sites are most responsive and lodgepole pine the recommended species (Brockley 1996 personal communication). Poor sites are usually limited by moisture availability rather than nutrients. One application can be used to reduce harvest

age by several years. Over six years post treatment (of thinned stands) one can expect a direct 15 m^3/ha net volume response. Average stand volume increases over 11 installations were 23 % and 32 % for two fertilization intensities with site indices ranging from 16 to 25 (Brockley, 1991). Growth is probably parallel thereafter. Repeat applications at regular intervals of 8-10 years can be expected to maintain this level of gain in Pine (Brockley 1996 personal communication).

Most fertilization trials have involved nitrogen alone. Lately there have been findings of synergistic response from sulfur and nitrogen mixes and so previously reported responses are probably conservative (Brockley, personal communication).

Early Acceleration of Height Growth

Fertilizer may also be used at or shortly after planting to accelerate height growth which will aid in competition with other vegetation and decrease time to cut-over green-up. However, there may be some risk due to the positive response of competing vegetation.

There appears to be little published work with regard to fertilization for reducing green-up. An MoF research note summarizes research and operational experience with fertilizing at time of planting. Generally, results are shown to be positive but increases are small and variable (B.C. MoF, 1995b). For this analysis, a sensitivity analysis approach would be appropriate and there is some consensus that one fertilization treatment between establishment and green-up would reduce the period by several years (Brockley, personal communication).

There is divergence in individuals' opinions within the Ministry of Forests as to the efficacy of early fertilization, with expectations related to geographic location. Interior Regions generally expect little improvement in green-up (Lister, personal communication) but coastal Regions expect significantly shortened green-up periods (Stewart, personal communication).

2.3 Yield Predictions

Using available tools and drawing on the above discussion of the literature, yield estimates can be made for use in forest level analysis. Commercial thinning and fertilization yield curves are produced with the goal of remaining conservative in estimation of response without missing any opportunities to realize benefits. Curves are built subjectively based on expectations from research results.

Although individual plots display much wide variation, the literature suggests average increases in accumulated volume due to commercial thinning of between zero and 10 %. Mortality is captured more completely by frequent light thinnings but these have economic limitations. Post thinning yield curves will be built based on managed stand yield curves modified to simulate one partial harvest and responses modelled will be 1) growth parallel to the base curve; 2) a five percent accumulated volume increase at harvest; and 3) a 10 %

accumulated increase. These three levels represent a full range of possible impacts. Forest level analysis using these curve sets provides a sensitivity analysis approach to the uncertainty associated with the yield predictions.

Figure 2.1 provides an example of how commercial thinning is modelled. When the thinning takes place the stand is moved from the higher yield curve to the lower and then tracks along the lower. The difference in volume between the two curves at the thinning age is the volume captured at thinning and added to the harvest volume. The example in Figure 2.1 represents the low end of the range of responses we have modelled, providing no net increase in accumulated volume as the lower curve is less than the upper by a constant volume (the volume removed at thinning).

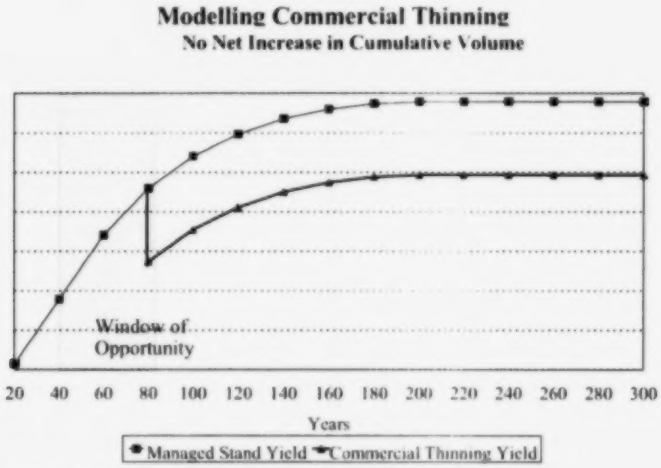
Modelling Commercial Thinning
No Net Increase in Cumulative Volume
Window of Opportunity
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Years
Managed Stand Yield
Commercial Thinning Yield

Figure 2.1 Example commercial thinning curve

Treatment response to fertilization appears to be limited to six and twelve years post treatment in the interior and coast respectively. Increases in volume (associated also with some thinning regimens) are in the -5 % to 30 % range within the post treatment impact window for spaced (managed) stands. Subjectively built curves will be based on maintaining a cumulative volume increase by repeat fertilization treatments. Figure 2.2 demonstrates such a curve and provides a graph of cumulative volumes harvested including thinnings.

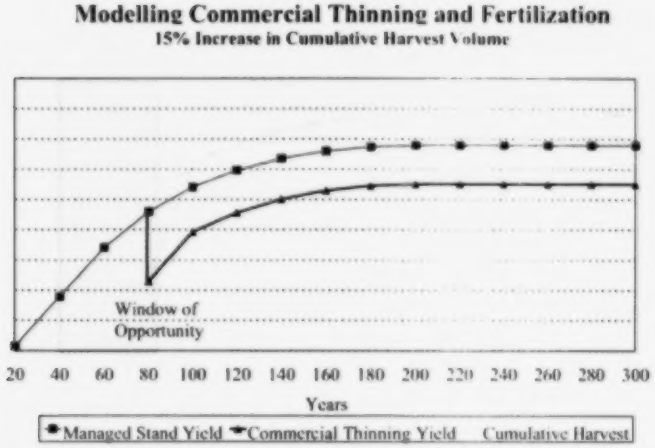
Modelling Commercial Thinning and Fertilization
15% Increase in Cumulative Harvest Volume
Window of Opportunity
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Years
Managed Stand Yield
Commercial Thinning Yield
Cumulative Harvest

Figure 2.2 Example commercial thinning and fertilization curve

As an alternate approach to subjectively building curves, TASS runs will be used for fertilization and commercial thinning.

The Tree and Stand Simulator (TASS) is a computer model that simulates the growth of individual trees and stands. It was developed by the Research Branch of the Ministry of Forests to assess the effects of silviculture treatments and environmental factors on stand growth and yield.

TASS is calibrated using fully stocked research plots and therefore requires adjustment to operational conditions. For the purposes of this analysis, the model was run with no operational adjustment factors (OAFs) in order that an accurate representation of all stems is maintained. OAFs were applied to the resulting curves before use.

Figure 2.3 provides a graphic comparison of yield curves which will be used in the Arrowsmith TSA analyses in Section 5.0. Illustrated is the set of yield curves for medium site Douglas-fir:

- The MoF TSR managed stand yield curve;
- The moderate stand response subjectively modified yield curve (5% accumulated yield increase);
- TASS control yield; and
- TASS treated curve (commercial thinning and repeated fertilization).

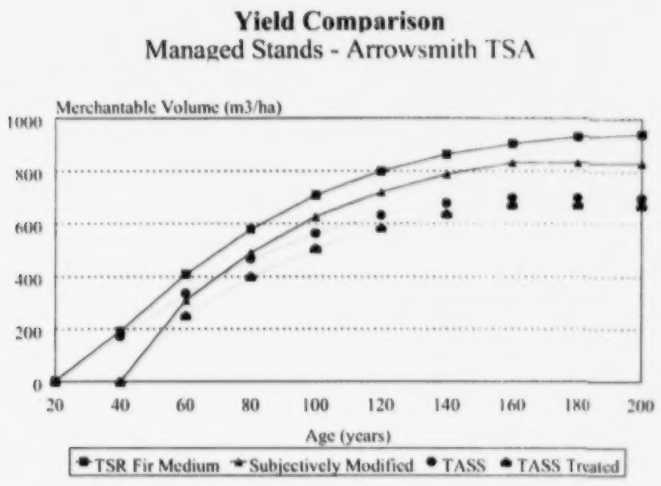

Figure 2.3 Yield comparison, TASS vs. subjectively modified curve

Typical of the yield curves used throughout the analysis, the TASS curves are lower.

There are some limitations to be considered in evaluating TASS fertilization runs. The model has not been calibrated for stands of lower site indices, lower densities, nor for multiple fertilizations (Jeff Stone 1997 personal communication).

3.0 FOREST LEVEL IMPACTS

This section provides a description of the mitigating effects that fertilization and commercial thinning can have on currently declining timber harvests by means of improved green-up rates, earlier availability of timber and partial harvesting in sensitive zones.

Timber supply analysis is the process of assessing and predicting the current and future supply of various resources from a management unit. An analysis evaluates how biological factors and management actions, including allowance for management of non-timber resources, affect the supply of harvestable timber over the short and long term. Land use, timber inventories, growth and yield assumptions, management intensities, formulation of the analysis problem and the modelling process all influence the harvest levels found to be achievable.

Inputs for forest level analysis for this project are drawn directly from MoF Timber Supply Review base case analyses. In expressing a preference for a certain harvest flow schedule one is balancing the needs of the present against the needs of future generations. Our approach to harvest scheduling, including the balancing of current and future harvest declines, is based on precedents set by the MoF. This maintains our ability to make direct comparisons to the TSR. Harvest levels start at the current AAC or as high as possible, with step downs limited to about 10 % per decade. Harvests may rise again thereafter due to increased yield from managed stands. The MoF generally holds decadal changes to a constant amount (each step down the same percentage). Our analyses differ slightly in harvest flow policy in that possible improvements in harvest level in any decade are captured. This results in some spiking of demonstrated benefits, however, these are real improvements over the base case.

In order to take advantage of inherent commercial thinning functionality, forest level analysis was undertaken using Timberline's proprietary model CASH_FM (Continuous Area Simulation of Harvesting and Forest Management). This simulation model, in a manner very similar to the MoF model FSSIM, explicitly considers management concerns such as visual quality objectives and habitat and water quality protection measures. CASH_FM traces its lineage through TIM-SIM and SQIRM (Timberline) and PlanTS (U.B.C.).

CASH_FM is used to determine a schedule of harvest for each scenario modelled by explicitly simulating integrated resource management by regulating forest cover. The scenarios modelled will be intensive silviculture regimes consisting of commercial thinning and/or fertilization.

Although stand volume increases are likely to be small, commercial thinning has the potential to positively impact timber supply. Commercial thinning has application in special management areas where clearcuts are not acceptable, where adjacency constraints are preventing harvest and through the access to stand volume in times

of shortage of timber above minimum harvest age. Forest estates likely to benefit are those with age class gaps and those where clearcut harvesting is restricted due to special management concerns.

Fertilization can also enhance harvest levels. Fertilizer treatments can increase volume and decrease minimum harvest ages. Early fertilization can also ameliorate the effects of forest cover constraints by accelerating green-up.

3.1 Age Class Distribution

An imbalance in age class distribution can lead directly to a timber supply shortfall. In a regulated forest each age class group or cohort, occupying the same number of hectares of land, contributes to the harvest in its turn as it becomes mature. In this scenario the harvest level remains constant over time. In a constrained timber supply situation, and if one age class group has significantly less area and therefore less volume at maturity, a fall down in harvest level will be necessitated until the next cohort becomes mature.

Figure 3.1 provides an illustration of how age class imbalance affects harvest flow. In decade one an overmature inventory with old, high volume stands allows harvest above the long term sustainable level. As we move to decade five or six the old stands are gone and although there is much young stock, little is available for harvest and declining harvests hit a low point. As we move to the fully regulated age structure harvest levels rise again to the sustainable level.

Age Class Distribution and Harvest Flow Over Time

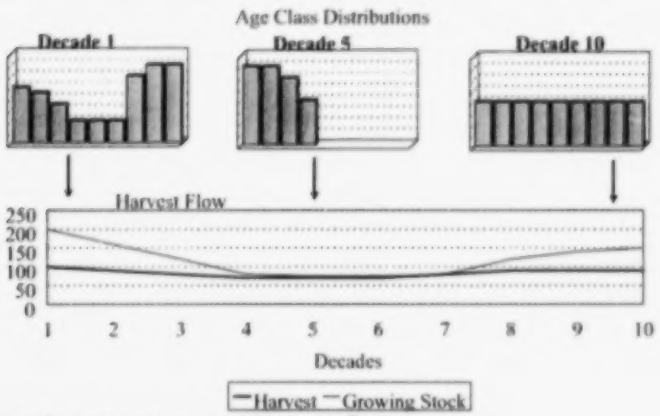

Figure 3.1 Age class structure and harvest flow

The decline in harvests can be ameliorated by partial harvests including commercial thinning in the younger age classes. Commercial thinning draws volume from younger stands to relieve the harvest volume shortfalls, without theoretically sacrificing future volumes or harvest opportunities in those stands.

Delaying final harvest improves benefits and where rotation ages are extended (in VQO zones for example) the impact can be large. On the other hand, changes in final harvest age can have negative impacts due to harvesting too soon and capturing lower volumes or harvesting too late and delaying availability of timber.

Fertilization can be used to increase stand diameter and volume and thereby reduce minimum harvest age. In this way a lack of harvest candidates can be addressed by increasing the pool of available stands and volume during critical periods.

3.2 Forest Cover Disturbance Constraints

Under integrated resource management a variety of objectives over and above timber requirements are recognized in each timber supply area. Management for these other resources and products translates to restrictions on the removal of forest cover and the distribution of those removals. Forest cover constraints place maximum limits on the disturbance of forest cover and minimum limits on the retention of old growth. In situations of restricted timber supply, fertilization and commercial thinning can be used to ease the impact of the disturbance forest cover constraints.

Partial harvests, including commercial thinning, can retrieve volume without compromising forest cover status. If residual stands retain the characteristics which define green-up, the harvested area is not considered disturbed and not included in the disturbance category for calculation of constraint status. If adjacency is a limiting factor, significant forest level improvements can be demonstrated independent of any stand level volume increase.

Similarly, fertilization may boost stand volume at harvest thereby decreasing the area harvested and ameliorating the impact of forest cover constraints.

3.3 Accelerated Green-up

Current planning and forest management modelling protocols involve the use of forest cover constraints to address integrated management issues. The use of limits on disturbance (harvesting) to model adjacency requirements and to ensure the desired distribution of age classes makes "time to green-up" an important factor in forest level analysis.

Green-up period is defined by the MoF as: "The time needed after harvesting for a stand of trees to reach a desired condition (e.g., height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics." If disturbance forest cover constraints are constraining harvest, harvest levels can be very sensitive to reductions in green-up period. Such a reduction can be accomplished by early fertilization.

A stand is said to have reached green-up when forest cover is well enough established that the stand is no longer considered to be in a disturbed condition. This is generally modelled by height development which is site index based. When fertilization is used in very young stands to accelerate green-up the assumption is that treatment results in a temporary indicated site index improvement and stands reach green-up sooner.

4.0 PROVINCIAL OPPORTUNITIES

There has been only limited use of commercial thinning or fertilization in B.C. However, area treated has been increasing, and the Forest Practices Code and Forest Renewal BC are seen as positive influences for future programs (Simons Reid Collins, 1996).

The identification of total provincial opportunities are beyond the scope of this project. This section reports our methodology in identifying individual timber supply areas for study of potential benefits to commercial thinning and fertilization. No extrapolation to other TSAs or roll-up to a provincial level can be derived from these analyses.

Timber Supply Analysis Reports and AAC Rationale Reports for 36 timber supply areas produced as part of the Provincial Timber Supply Review Project have been reviewed. Each TSA was evaluated for potential use as a test case for forest level analysis of the benefits to commercial thinning and fertilization.

The evaluation considered:

- Forest structure, specifically gaps in the age class distribution, that could benefit from treatment;
- Constrained timber supply situations which would be sensitive to changes in silviculture regime;
- The presence of suitable stands for treatment;
- Relative exposure to strict forest or landscape management requirements which would increase forest level sensitivity to incremental regimes;
- Specific sensitivities to changes in green-up guidelines, forest cover requirements and minimum harvest ages; and
- Past or planned activity in partial harvests or fertilization.

The TSR program generally did not address incremental silviculture, as funding and activity levels have been low and inconsistent. Exceptions to this are Kalum South for which commercial thinning was considered base case, and Arrowsmith where some MoF post-TSR analysis considers sensitivities around commercial thinning and fertilization.

The AAC Rationale documents often refer to possible forest level benefits from commercial thinning and fertilization. Where there is some past performance in the use of fertilizer, the effect is deemed small and/or to only marginally affect the short term harvest (*e.g.* Fraser, Merritt, Strathcona) or not at all (*e.g.* Boundary, Cranbrook). Responses to commercial thinning are regarded as requiring further study before they can be incorporated into an AAC determination (various AAC Rationale documents).

In addition to the review of TSR materials each Regional Stand Tending Forester was consulted on past, current and planned programs, tending regimes, opportunities for timber supply impacts and product markets.

4.1 Selection of Test Cases

Certain TSAs in the Vancouver Region have significant commercial thinning and fertilization programs, notably the Strathcona and the Soo. Several TSAs including the Arrowsmith have forest structure characteristics which promise benefits to treatment. Much of the commercial thinning data available is based on plot data within the Arrowsmith TSA. Markets exist for thinning products. Proximity to large urban centres and busy recreation destinations impose inordinate pressures on the more southern TSAs, some of which can be ameliorated with commercial thinning.

The timber supply situation in the Cariboo Region is comparatively strong, providing little opportunity to realize AAC benefits in the short term from commercial thinning and fertilizing. It is unlikely that commercial thinning will be of great importance in the Region, although the same is not true of fertilization. Selected TSAs should present a full range of possible benefits.

Although there has been little commercial thinning in the Nelson Region, there is a notable use of partial harvests. With some TSAs facing declines in harvest levels and having suitable age class distributions there are possibilities for impacts at the forest level. These would result from stand level activities which increase harvest flexibility. There are markets for thinning products such as small sawlogs and wood chips. Some fertilization is done but the program is prone to budget cuts.

In the Prince Rupert Region lumber prices are currently too low to support commercial thinning, indicating that it is more of a marginal proposition than in other Regions. There has been some activity in last 3 years in the Morice and Kalum TSAs. Motivation for commercial thinning is primarily to create harvest opportunities and address an age class distribution problem. No fertilization has been done since 1989 but a small program is planned for the coming year. The prevalent fertilization treatment will be post spacing, with periodic re-treatment until harvest. Commercially thinned stands would have high priority for fertilizing. However, funding for fertilization has been sacrificed in times of fiscal restraint and the program depends on FRBC funding.

Opportunities for harvest level benefits from commercial thinning and fertilization are limited in the Prince George Region. There are no age class imbalances or critical timber supply situations to address and a limited response would be expected from the natural stand candidates found throughout the Region. Although there are some market opportunities for thinning materials, there are serious economic limitations associated with partial harvests light enough to maintain growing stock and capture mortality.

Two TSAs, one coastal and one interior, have been chosen as initial test cases. These are meant to demonstrate effects and possible benefits. There are other TSAs which would be interesting to analyse. These we must leave for future work which will be able to build on the methods of this report.

5.0 ARROWSMITH TSA ANALYSIS

The Arrowsmith TSA is composed of the South Island Forest District, previously the Duncan and Port Alberni Forest Districts. Quite fragmented, it consists of 168,000 ha (124,000 productive ha) distributed amongst private land and Tree Farm Licences.

The Arrowsmith TSA was chosen as a test case for the following reasons:

- The TSA exhibits conditions and characteristics which can result in timber supply benefits to both fertilization and commercial thinning. This includes a largely immature forest on the east side of the island which, however, has few stands between 10 and 30 years of age;
- A revised MoF Timber Supply Review (TSR) indicates that the current harvest level can be maintained for one decade followed by four 12 % per decade step downs;
- The TSR indicated sensitivity in the short term to changes in green-up periods and forest cover requirements;
- Commercial thinning and fertilization are practiced in the TSA but were not modelled in the TSR report;
- Subsequent MoF analysis of commercial thinning and fertilization effects on the TSA indicate mid and long term benefits; and
- A TSA licencee report on timber supply analysed commercial thinning using yield curves produced by the MoF for the above mentioned analysis and showed a short term impact on timber supply.

5.1 Establishing a Base Case

Forest level modelling input files for an MoF revised TSR base case were obtained and converted to the format required by the Timberline model CASH_FM. Input documentation can be found in the Arrowsmith TSA Timber Supply Analysis (August 1995). The revised base case differs from the TSR documentation in several ways. The land base was changed and this caused slight changes in forest cover requirements and yield curves. Future road assumptions changed as well.

A base case provides the assurance that the appropriate data is being used and that the modelling problem has been formulated correctly. As demonstrated in Figure 5.1, our results with CASH_FM are slightly more optimistic in the mid and long term than the MoF analysis. This is acceptable as a base however, as the benefits to commercial thinning and fertilizing are best considered as marginal improvements, not absolute values.

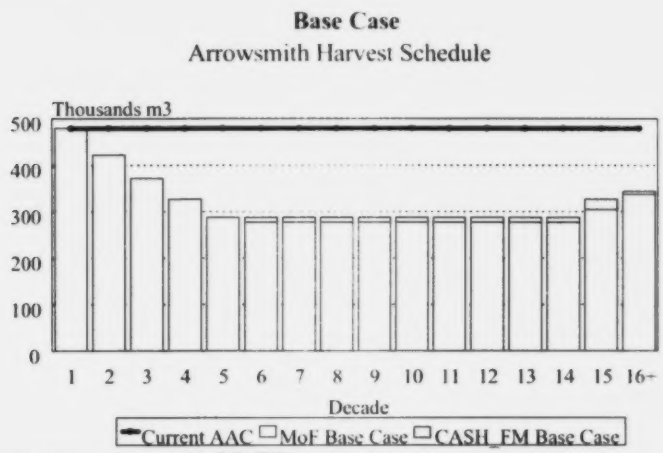

Figure 5.1 Base case - Arrowsmith TSA

5.2 Treatment Regimes

The literature suggests candidates for commercial thinning should be Douglas-fir stands on medium or good sites. Fertilization is indicated for all sites in natural stands (but could be more targeted in managed stands to medium sites). Based on the literature and on existing local programs, this analysis considers all Douglas-fir leading stands on the east side of the island as candidates for commercial thinning and fertilization. For these stands only, TSR managed stand yield curves are subjectively modified to reflect post-treatment volume yields.

Three regimes are modelled: commercial thinning only; fertilization only; and commercial thinning and fertilization.

Using a sensitivity approach, uncertainty in yield estimates are addressed by three response levels based on the net increase in accumulated volume (Table 5.1). This provides the reader with forest level analysis results whatever his or her opinion is of stand level responses. The net increase in accumulated volume means that at any point in stand development, harvest volume plus thinning volume will be some percentage higher than the untreated stand harvested at the same age. The range of increases in volume reflect the available literature and current observations of field managers.

Table 5.1. Commercial thinning and fertilizing regimes - Arrowsmith TSA

Regime	Net Increase In Accumulated Volume		
	Low	Moderate	High
Commercial thinning only	0%	5%	10%
Fertilization only (managed stands only)	5%	15%	25%
Commercial thinning and fertilization	5%*	20%	35%

* Due to the approach taken to implementation of yield curves low response to commercial thinning and fertilization (five percent) will provide the same results as moderate response (five percent) to commercial thinning only.

In order to model commercial thinning and fertilization several modifications are made to the analysis problem definition as outlined in the TSR.

Commercial Thinning
Thinning treatments for candidate stands are defined in the model and the specific analysis units are given a 20 year treatment "window of opportunity" within which they can be treated and moved to a post treatment analysis unit. A maximum annual thinning limit of 300 ha was set. Three hundred ha was in line with District recommendations and often available candidates were more limiting as indicated during modelling.

Fertilization
A general fertilization regime with no thinning. In order to put some practical limit on the program, fertilization is limited to Douglas fir managed stands. All treated stands are presumed to have multiple fertilizer treatments. Early fertilization for green-up will not be handled using yield curves but will be translated into incremental changes to green-up ages (Section 5.4).

Commercial Thinning and Fertilization
Fertilization in combination with commercial thinning is modelled in a manner similar to commercial thinning only, however expected yield responses are higher.

5.3 Analysis - Commercial Thinning and Fertilization

Analysis results are presented below in a set of Figures which compare the base case to harvest schedules possible with the three incremental regimes (Figures 5.2, 5.3, 5.4) and the three response levels discussed above (low, moderate, high). Increases in response are displayed incrementally to the base case analysis.

As discussed above (Section 3.0), harvest flow policy can have a major impact on results, particularly on the timing of benefits. For these analyses the preference is to have benefits accrue as soon as possible to soften short term falldown, with improvements in the mid and long term a lower priority.

Commercial Thinning Only

This is a commercial thinning only regime. Douglas-fir leading stands on the east side of the TSA (about 30 % of the net land base) are available for treatment, up to a 300 ha per year limit. Commercial thinning entries are between 35 and 60 years. Forty percent of the volume is removed.

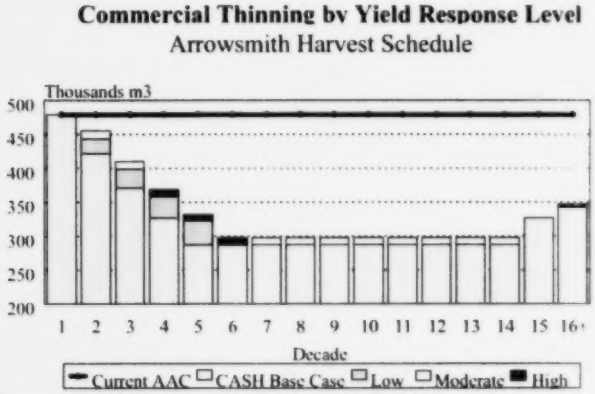

Figure 5.2 Commercial thinning - Arrowsmith TSA

Table 5.2 Harvest schedule - commercial thinning (m^3)

Decade	Base Case	Low Response[1] (0%)			Moderate Response (5%)			High Response (10%)		
		Ha Treated[2]	Change in Harvest Level[3]	(%)	Ha Treated	Change in Harvest Level	(%)	Ha Treated	Change in Harvest Level	(%)
1	4,791,500	3,000	0	0	3,000	0	0	3,000	0	0
2	4,216,520	3,000	215,610	5	3,000	335,410	8	3,000	335,410	8
3	3,710,540	468	278,370	8	468	386,200	10	468	386,200	10
4	3,265,270	732	324,730	10	754	339,730	10	772	421,730	13
5	2,873,500	1,695	357,520	12	1,747	371,000	13	1,821	444,500	15
6	2,873,500	1,627	26,500	1	1,780	106,500	4	1,692	106,500	4
7	2,873,500	2,244	0	0	2,785	106,500	4	2,899	106,500	4
8	2,873,500	2,816	0	0	2,449	106,500	4	2,662	106,500	4
9	2,873,500	1,011	0	0	1,527	106,500	4	1,424	106,500	4
10	2,873,500	1,622	0	0	1,496	106,500	4	1,513	106,500	4
long -term	3,428,500[4]		-48,500	-1		0	0		41,500	1

[1] Response is net increase in yield curve accumulated volume.
[2] Treatment is by decade.
[3] Change values are total from base case, not incremental as in the Figure above.
[4] The annual long term harvest is 342,850m^3

Fertilization Only

This is a fertilization only regime. Only managed stands are candidates. Douglas-fir leading stands on the east side of the TSA (about 30 % of the net land base) are available for treatment once they move to managed stand curves. There is no annual limit to treatment, all managed stands on the east side are on a repetitive fertilization program.

Fertilization by Yield Response Level
Arrowsmith Harvest Schedule

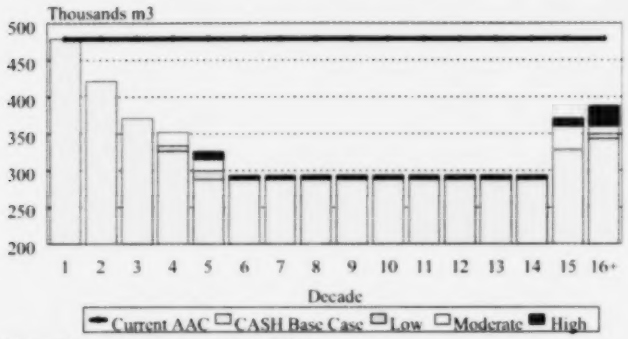

Figure 5.3 Fertilization - Arrowsmith TSA

Table 5.3 Harvest schedule - fertilization (m^3)

Decade	Base Case	Low Response[1] (5%)		Moderate Response (15%)		High Response (25%)	
		Change in Harvest Level[2]	(%)	Change in Harvest Level	(%)	Change in Harvest Level	(%)
1	4,791,500	0	0	0	0	0	0
2	4,216,520	0	0	0	0	0	0
3	3,710,540	0	0	0	0	0	0
4	3,265,270	74,730	2	259,730	8	259,730	8
5	2,873,500	131,500	5	299,000	10	387,120	13
6	2,873,500	0	0	0	0	61,500	2
7	2,873,500	0	0	0	0	61,500	2
8	2,873,500	0	0	0	0	61,500	2
9	2,873,500	0	0	0	0	61,500	2
10	2,873,500	0	0	0	0	61,500	2
long-term	3,428,500[3]	71,500	2	171,500	5	453,000	13

[1] Response is net increase in yield curve accumulated volume.
[2] Change values are total from base case, not incremental as in the Figure above.
[3] The annual long term harvest is 342,850m^3

Fertilization is providing some short term and mid term gains. There is not a large old growth component in the inventory to support increased earlier harvests based on the higher volume managed stands coming available later. Long term gains are not directly

proportional to treatment response levels due to the limited proportion of the land base treated.

The above results may be conservative since minimum harvest ages have not been adjusted downward as may be appropriate. Additional analysis was undertaken based on the moderate fertilization scenario but with minimum harvest ages for fertilized stands reduced by five years and by 10 %. Although mature and available volumes increased through the modelling time frame the long term increase in harvest flow was about one percent in both cases. This is in line with MoF TSR sensitivity analysis.

Commercial Thinning and Fertilization

This is a commercial thinning regime with fertilization in thinned stands only. Douglas-fir leading stands on the east side of the TSA (approximately 30 % of the net land base) are available for treatment, up to a 300 ha per year limit. Commercial thinning entries are between 35 and 60 years. Forty percent of the volume is removed.

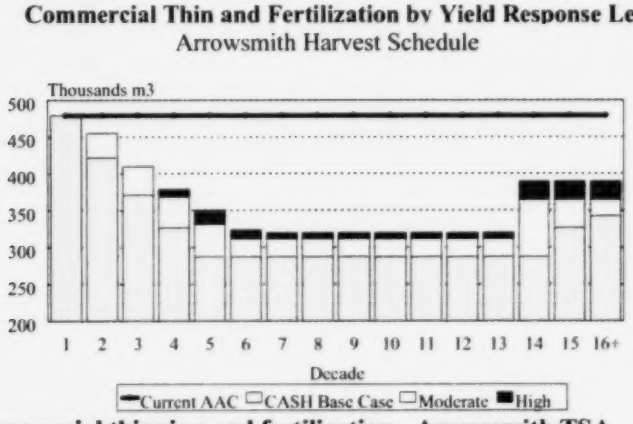

Figure 5.4 Commercial thinning and fertilization - Arrowsmith TSA

Table 5.4 Harvest schedule - commercial thinning and fertilization (m^3)

Decade	Base Case	Moderate Response[1] (20%)			High Response (35%)		
		Ha Treated[2]	Change in Harvest Level[3]	(%)	Ha Treated	Change in Harvest Level	(%)
1	4,791,500	3,000	0	0	3,000	0	0
2	4,216,520	3,000	335,410	8	3,000	335,410	8
3	3,710,540	468	386,460	10	468	386,460	10
4	3,265,270	777	421,730	13	777	524,730	16
5	2,873,500	1,650	444,500	16	1,650	631,500	22
6	2,873,500	1,735	246,500	9	1,735	369,000	13
7	2,873,500	2,273	246,500	9	2,273	326,500	11
8	2,873,500	3,000	246,500	9	3,000	326,500	11
9	2,873,500	1,580	246,500	9	1,845	326,500	11
10	2,873,500	1,484	246,500	9	1,774	326,500	11
long-term	3,428,500[4]		221,500	7		471,500	14

[1] Response is net increase in yield curve accumulated volume.
[2] Treatment is by decade.
[3] Change values are total from base case, not incremental as in the Figure above.
[4] The annual long term harvest is 342,850m^3

Commercial thinning in combination with fertilization can be expected, under appropriate conditions, to yield significant short and long term harvest level benefits in the Arrowsmith TSA.

5.4 Analysis - Accelerated Green-up

Analysis of early fertilization for accelerated green-up uses a sensitivity approach and modified green-up ages within the context of forest cover constraints. In order to maintain the ability to make comparisons to other scenarios, treatments should be assumed to be limited to the same east side Douglas-fir leading stands. However, actual model control of green-up is at the zone level and the three east side zones have green-up ages reduced for all analysis units. This represents an overestimate of areas to be fertilized, but involves only 1,500 ha (approximately) of other conifer leading stands.

Two levels of impact were analysed based on discussions with MoF researchers and field managers. In the first, green-ups are reduced by two years. In the second they are reduced by 50 %. In both cases changes to green-up are for all stands but limited to the east-side of the island.

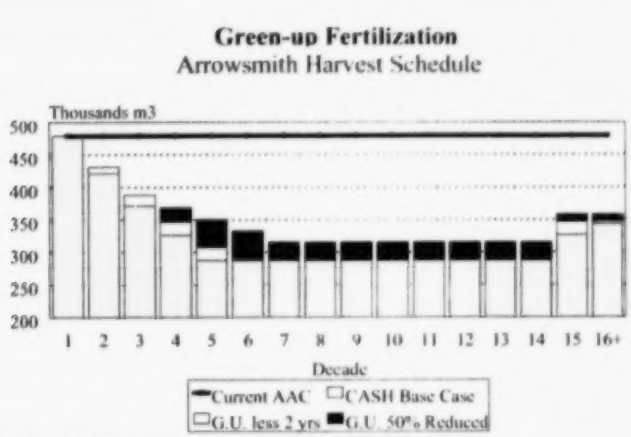

Figure 5.5 Accelerated green-up - Arrowsmith TSA

Table 5.5 Harvest schedule - green-up fertilization (m^3)

Decade	Base Case	Green-up less 2 years		Green-up 50% reduced	
		Change in Harvest Level [1]	(%)	Change in Harvest Level	(%)
1	4,791,500	0	0	0	0
2	4,216,520	95,830	2	95,830	2
3	3,710,540	170,570	5	170,570	5
4	3,265,270	204,730	6	421,730	13
5	2,873,500	200,340	7	626,500	22
6	2,873,500	0	0	454,500	16
7	2,873,500	0	0	276,500	10
8	2,873,500	0	0	276,500	10
9	2,873,500	0	0	276,500	10
10	2,873,500	0	0	276,500	10
long-term	3,428,500[2]	41,500	1	151,500	4

[1] Change values are total from base case, not incremental as in the Figure above.
[2] The annual long term harvest is 342,850m^3

In the Arrowsmith TSA, increases in harvest due to fertilization for accelerated green-up start to appear in the second decade and peak in the seven to 22 % range in decade five.

5.5 Alternate Analysis using TASS Yields

A second analysis of commercial thinning and fertilization on the Arrowsmith TSA was undertaken to compare and confirm results. In this alternate analysis TASS yield curves which directly model commercial thinning and fertilizing are used.

Yield Prediction

For their own analyses the MoF produced TASS runs for various silviculture treatments of Douglas-fir in the Arrowsmith TSA. For this analysis we have drawn on that work and used MoF yield curves based on the following commercial thinning and fertilizing regimes in Table 5.6

Table 5.6 Silviculture regimes for TASS yields

Site Class	Initial Density	Space	Commercial Thin	First Fertilization	Second Fertilization
Managed Stands					
Medium	1200 sph	700 sph @ 6m	325 sph @ 45 yrs.	48 yrs..	58 yrs.
Good	1200 sph	700 sph @ 6m	325 sph @ 35 yrs.	n/a	n.a
Existing Stands					
Poor	3000 sph	n/a	350 sph @ 50 yrs.	40 yrs..	
Medium	3000 sph	n/a	350 sph @ 50 yrs.	40 yrs..	53 yrs.
Good	3000 sph	n/a	350 sph @ 50 yrs.	40 yrs..	

An initial set of curves based on the above regimes was prepared with operational adjustment factors (OAFs) as used in the TSR managed curves: OAF1 = 15 % and OAF2 = 16.9 %. The OAF2 was set higher than standard practice due to concerns with root rot. There is some concern that an OAF2 of 16.9 % is too high for managed stands given the positive impact of low thinnings in which root rot centres are removed. For this reason commercial thinning curves using standard OAFs of 15 % and five percent were created as well.

Establishing a Base Case

In order to accurately isolate commercial thinning and fertilizing impacts, TASS control (no treatment) yields were used in the place of Douglas-fir existing and managed stand curves. The results are compared to the CASH base case in Figure 5.6 below.

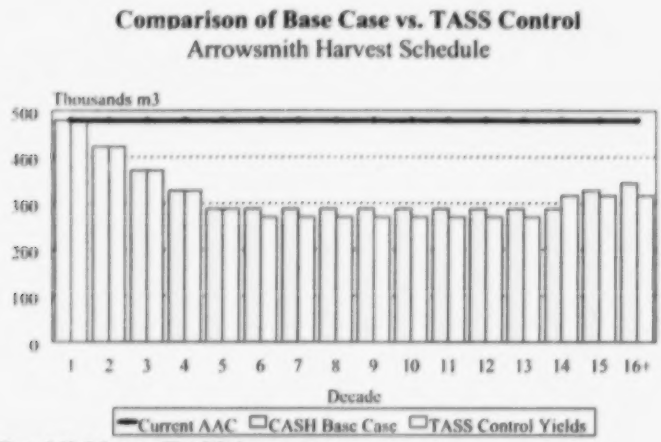

Figure 5.6 - Establishing a TASS base case

Analysis

Using the same model functionality as the other thinning scenarios, the TASS commercial thinning and fertilizing yields resulted in a harvest flow scenario as presented in Figure 5.7. Reduced OAFs refers to use of the OAF2 = five percent curves developed for thinned stands based on reduction of root rot incidence after treatment.

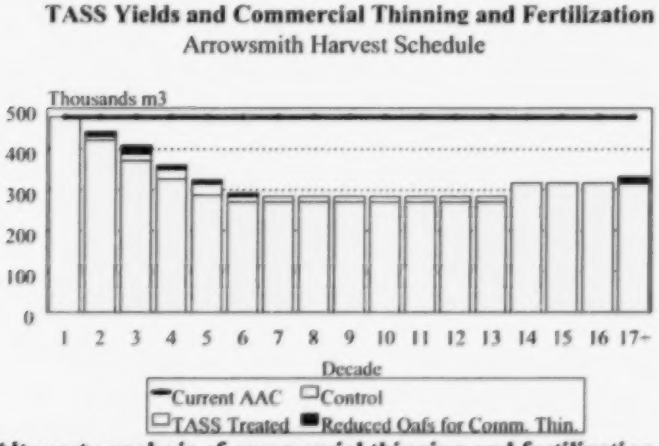

Figure 5.7 - Alternate analysis of commercial thinning and fertilization

Table 5.7 Harvest Schedule TASS Yields (m^3)

Decade	TASS Base	Commercial Thin and Fertilize			Reduced OAFs		
		Ha Treated[1]	Change in Harvest Level[2]	Change (%)	Ha Treated	Change in Harvest Level	Change (%)
1	4,791,500	3,000	0	0	3,000	0	0
2	4,216,520	3,000	93,480	2	3,000	213,480	5
3	3,710,540	468	169,460	5	468	384,460	10
4	3,265,270	796	227,730	7	796	334,730	10
5	2,873,500	1,530	270,500	9	1,689	366,500	13
6	2,700,000	1,666	130,000	5	1,752	220,000	8
7	2,700,000	1,641	130,000	5	2,482	130,000	5
8	2,700,000	3,000	130,000	5	2,407	130,000	5
9	2,700,000	1,637	130,000	5	1,461	130,000	5
10	2,700,000	778	130,000	5	1,472	130,000	5
long-term	3,160,000[3]		0	0		160,000	5

[1] Treatment is by decade.

[2] Change values are total from base case, not incremental as in the Figure above.

[3] The annual long term harvest is 316,000m^3

The analysis using TASS yields indicates results similar to those of the moderate response to commercial thinning (or the low response level to commercial thinning and fertilization). Short term improvements in harvest peak in decade five at between nine and 13 %.

5.6 A Management Scenario for the Arrowsmith TSA

Results from the preceding analyses are drawn upon to define a reasonable thinning and fertilizing regime for the TSA. Analyses based on subjectively modified curves were compared to the TASS analysis. A moderate regime was identified that may represent a practical set of opportunities on the TSA. It is, however, only one example of the many possible combinations of stand treatments and harvest flow scenarios.

For this regime, increases in yields (10 % total volume increment) are reflective of the high range of expected response to commercial thinning only. This corresponds to between the low and moderate response expectations to treatment with commercial thinning and fertilizing. A maximum commercial thinning program of 300 ha per year is assumed. Early fertilization is used to reduce green-up ages by two years. Managed stands on the east side of the island that do not undergo commercial thinning are subjected to a general fertilization program with moderate (15 %) response. The resulting harvest schedule is presented in Figure 5.8.

Regime Summary

- Treatments on east side of island only (30 % of land base).
- Commercial thinning and fertilizing:
  10 % increase in accumulated volume,
  treatment limit of 300 ha per year.
- General fertilization program:
  managed stands not thinned,
  15 % increase in accumulated volume.
- Early fertilizing reduces green-up by two years.

Management Scenario
Arrowsmith Harvest Schedule

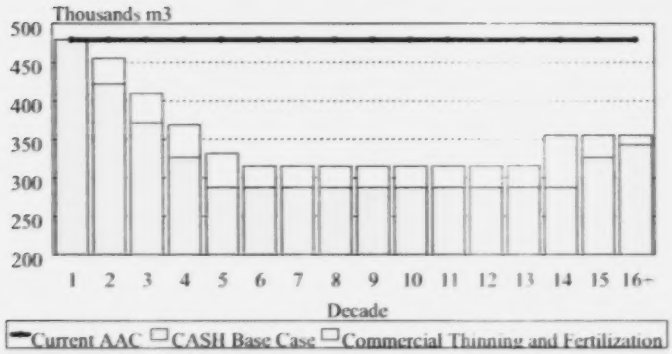

Figure 5.8 - Management Scenario

Table 5.8 Harvest schedule management scenario (m^3)

Decade	Base Case	Ha Treated by Decade	Change in Harvest Level [1]	Change (%)
1	4,791,500	3,000	0	0
2	4,216,520	3,000	335,410	8
3	3,710,540	486	386,460	10
4	3,265,270	740	421,730	13
5	2,873,500	1,752	444,500	15
6	2,873,500	1,974	276,500	10
7	2,873,500	2,718	276,500	10
8	2,873,500	2,295	276,500	10
9	2,873,500	1,635	276,500	10
10	2,873,500	1,329	276,500	10
long-term	3,428,500[2]		121,500	4

[1] Change values are total from base case, not incremental as in the Figure above.
[2] The annual long term harvest is 342,850m^3

Short term increases in harvest levels range from zero in the first decade to 15 % in decade five. These short term results reflect volume obtained from commercial thinning. The

long term increase of four percent is largely due to higher volumes associated with fertilization.

5.7 Discussion

Analysis of the Arrowsmith TSA is complicated by the very different situations on the east versus west side of the island. There are large differences in species and age distributions which really amount to two separate analysis situations. All impacts from incremental treatments investigated here are to some degree diluted because treatments are limited to Douglas-fir leading candidates on the east side of the TSA (approximately 30 % of the net harvesting land base).

The MoF TSR analysis used species and site groupings for analysis units which where suitable for extension to an analysis of commercial thinning and fertilizing. The use of a high (16.9 %) operational adjustment factor for endemic losses (OAF2) as defined in the TSR may be underestimating yields in managed stands.

Results indicate that commercial thinning and fertilization may be used on the Arrowsmith TSA to counteract the decline in harvest levels required as management moves toward the integration of various resource requirements.

Fertilization as a stand alone treatment for all Douglas-fir managed stands demonstrates some mid term benefits–one or two decades only with impacts ranging between two and 13 %. Most impact is in the long term–two percent, five percent and 13 % for low, moderate and high stand level response respectively. There is no pool of older stands to support higher short term harvests (allowable cut effect) which would be possible given the higher long term yields.

In our analyses, commercial thinning, as a stand alone treatment or in combination with fertilization, is providing a cushioning effect on harvest falldown without negatively impacting sustainable harvest levels. It is doing this by harvesting volume through commercial thinning without impacting the otherwise limiting forest cover constraints. Short term benefits range from eight to 22 %. Long term benefits (from one to 14 percent) accrue from the fertilization induced higher stand volumes. No benefits are shown in the first decade because we have chosen to cap harvest levels at the current AAC.

Early fertilizing for acceleration of green-up is a promising option. There is no data available to support the stand level impacts used but the range of opinion is two years to 50 % reductions in green-up. These two levels demonstrated short term impacts peaking at seven and 22 % respectively at decade five. Long term benefits were one to four percent.

The TASS yields analysis demonstrated results similar to the moderate response to commercial thinning analysis. Short term benefits were improved significantly with the operational adjustment modified for reduced risk from root rot.

The general approach to analysis in this report is to provide ranges of values within which one may choose results felt to be reasonable. In order to demonstrate the utility of such analyses to strategic planning for silviculture, one management scenario was chosen as a reasonable example silviculture program. The goal is to represent a practical set of opportunities on the TSA to ameliorate declining harvests. This management scenario promises short term harvest gains of up to 15 % and long term increases of four percent.

6.0 KOOTENAY LAKE TSA ANALYSIS

The Kootenay Lake TSA is generally mountainous terrain centred around Kootenay Lake in the south-central interior of British Columbia. It covers 1.13 million hectares, half of which is productive forest.

The Kootenay Lake TSA was chosen for analysis for the following reasons:

- 45 % of the land base is in watershed zones with extended green-up ages;
- 25 % of the land base is in visual quality zones with both extended green-up ages and a lower maximum rate of disturbance;
- The Chief Forester reduced the AAC by 22 % in the first decade;
- In the first four decades forest cover guidelines are limiting;
- Timber supply analysis is sensitive in the short term to tighter constraints defined by forest cover ages. The pattern is the same for minimum harvest ages;
- The analysis was even more sensitive to relaxing forest cover percentages; and
- There is strong potential for silviculture practices to reduce green-up for short term benefit.

6.1 Establishing a Base Case

All inventory and analysis inputs to these analyses are as published in the MoF Kootenay Lake TSR. Ministry of Forests TSR analysis units will be maintained and managed stand curves and commercial thinning and fertilizing curves produced for this project will be based on them. Unfortunately the TSR used aggregations across site classes to create analysis units. This tends to mask responses such as green-up, which are sensitive to site index.

Figure 6.1 provides a comparison between CASH_FM and the TSR results in the Kootenay Lake TSA. In this case CASH_FM provides a less optimistic outlook. Again, this is acceptable as we are concerned with magnitudes of improvement not absolute values of sustainable harvests.

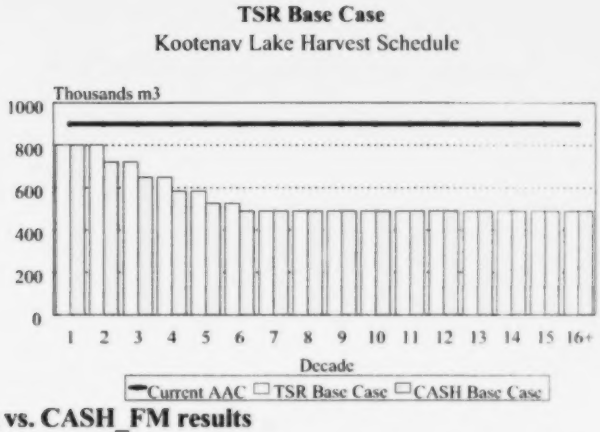

Figure 6.1 TSR vs. CASH_FM results

The Kootenay Lake TSR did not use managed stand yield curves. An analysis of commercial thinning and fertilizing requires the use of such curves. The MoF model Table Interpolation of Stand Yields (WINTIPSY) was used to build curves based on TSR analysis units and pooled area weighted site indices. Included in the base case is the use of green-up ages driven by site index curves. Figure 6.2 illustrates the base case established for further analysis.

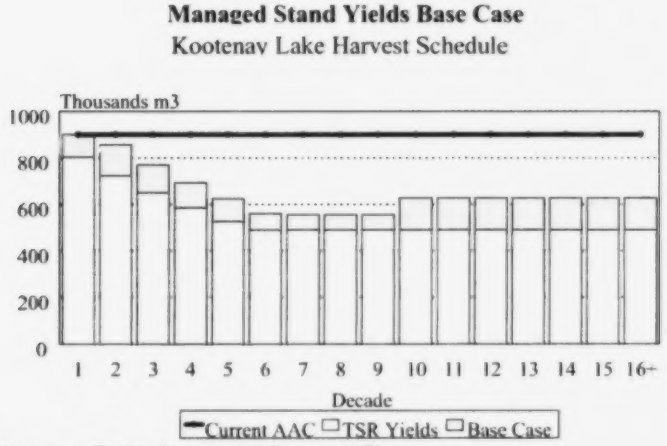

Figure 6.2 Kootenay Lake base case harvest flow

6.2 Treatment Regimes

The literature suggests candidates for commercial thinning should be lodgepole pine. However, in the Kootenay Lake TSA lodgepole pine represents only 20 % of the operable forested land base, Douglas-fir and Douglas-fir/larch or "Kootenay" mixes are also important candidates. Fertilization is indicated in lodgepole pine and wet belt Douglas-fir.

Subjective curves were built as described in Section 2.3. Thinning and fertilization curves were built for TSR analysis units consisting of fir/larch/pine mixes.

Regimes and response levels modelled (identical to the Arrowsmith analysis) are presented in Table 6.1.

Table 6.1. Commercial thinning and fertilizing regimes - Kootenay Lake TSA

Regime	Net Increase In Accumulated Volume		
	Low	Moderate	High
Commercial thinning only	0%	5%	10%
Fertilization only (managed stands only)	5%	15%	25%
Commercial thinning and fertilization	5%*	20%	35%

* Due to the approach taken to implementation of yield curves low response to commercial thinning and fertilization (five percent) will provide the same results as moderate response (five percent) to commercial thinning only.

Early fertilization for green-up will not be handled using yield curves but will be translated into incremental changes to green-up ages (Section 6.4).

6.3 Analysis - Commercial Thinning and Fertilization

Commercial Thinning Only

This is a commercial thinning only regime. Thinning removes 50 % of the volume from 70 year old managed stands and 80 year old natural stands. Thinning candidates are the Douglas-fir mixes. Cedar and spruce leading stands are not candidates. After discussion with the District, a 300 ha per year maximum was set for the thinning program. This was based on a compromise between apparent biological opportunity and administrative capabilities. Final harvests are delayed for a minimum of twenty years post thinning.

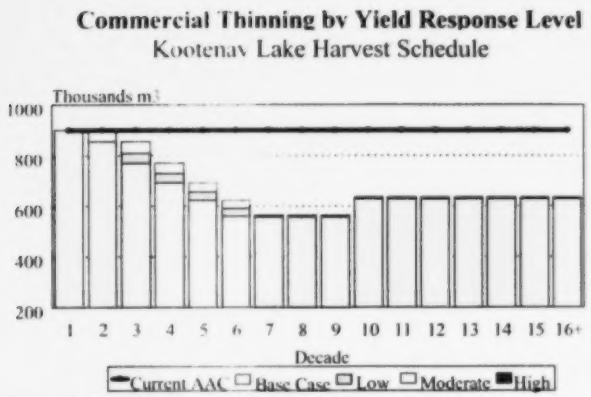

Figure 6.3 Commercial thinning - Kootenay Lake TSA

Table 6.2 Harvest schedule - commercial thinning (m^3)

Decade	Base Case	Low Response[1] (0%)		Moderate Response (5%)		High Response (10%)	
		Change in Harvest Level[2]	(%)	Change in Harvest Level	(%)	Change in Harvest Level	(%)
1	9,000,000	0	0	0	0	0	0
2	8,550,000	0	0	450,000	5	450,000	5
3	7,695,000	405,000	5	855,000	11	855,000	11
4	6,925,000	365,000	5	770,000	11	770,000	11
5	6,230,000	330,000	5	695,000	11	695,000	11
6	5,600,000	300,000	5	630,000	11	630,000	11
7	5,560,000	0	0	70,000	1	70,000	1
8	5,560,000	0	0	70,000	1	70,000	1
9	5,560,000	0	0	70,000	1	70,000	1
long-term	6,280,000[3]	0	0	0	0	60,000	1

[1] Response is net increase in yield curve accumulated volume.
[2] Change values are total from base case, not incremental as in the Figure above.
[3] The annual long term harvest is 628,000m^3
The full treatment budget of 300 ha per year is used every year in all three response scenarios.

Benefits are limited to the short term and are in the five to 11 % range. Key to achieving the increased harvest levels associated with the moderate and high responses is leaving the commercially thinned stands long enough to realize the higher volumes levels.

Fertilization Only

This fertilization only regime applies to all managed stands, no natural stands. There is no commercial thinning, Douglas-fir mixes are candidates.

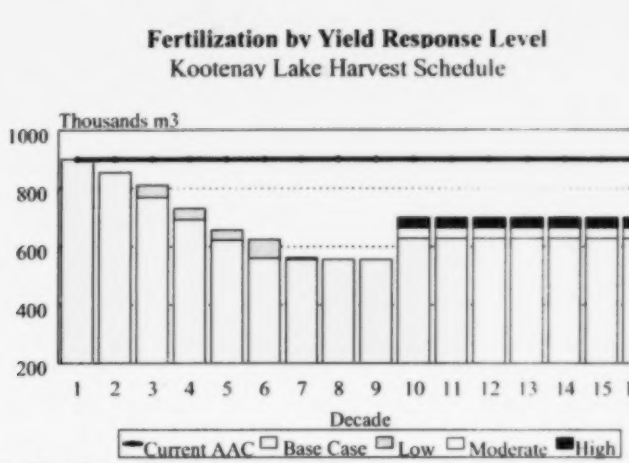

Figure 6.4 Fertilization - Kootenay Lake TSA

Table 6.3 Harvest schedule - fertilization (m^3)

Decade	Base Case	Low Response[1] (5%)		Moderate Response (15%)		High Response (25%)	
		Change in Harvest Level[2]	(%)	Change in Harvest Level	(%)	Change in Harvest Level	(%)
1	9,000,000	0	0	0	0	0	0
2	8,550,000	0	0	0	0	0	0
3	7,695,000	425,000	6	425,000	6	425,000	6
4	6,925,000	385,000	6	385,000	6	385,000	6
5	6,230,000	340,000	6	340,000	6	340,000	6
6	5,600,000	650,000	12	650,000	12	650,000	12
7	5,560,000	0	0	60,000	1	60,000	1
8	5,560,000	0	0	0	0	0	0
9	5,560,000	0	0	0	0	0	0
long-term	6,280,000[3]	0	0	360,000	6	720,000	12

[1] Response is net increase in yield curve accumulated volume.
[2] Change values are total from base case, not incremental as in the Figure above.
[3] The annual long term harvest is 628,000m^3

Fertilization demonstrates benefits in the short and long terms. Short term gains (six to 12 %) are based on increased harvesting of old growth permitted by higher volume managed stands coming on stream later. Long term gains are based on higher managed stand volumes.

An additional analysis was undertaken based on the moderate fertilization scenario but with minimum harvest ages for fertilized stands reduced by 5 years (from 80 to 75 years). Although mature and available volumes increased through the modelling time frame no significant increase in harvest flow was possible. This is in line with MoF TSR sensitivity analysis.

Commercial Thinning and Fertilization

Commercial thinning in combination with fertilization is limited to Douglas-fir mixes. A maximum 300 ha per year is set. This regime includes no fertilization program other than post thinning. Thinning is a 50 % volume removal. This is set at a relatively intense level to ensure an economically feasible volume removed during modelling.

Commercial Thinning and Fertilization by Yield Response Level
Kootenay Lake Harvest Schedule

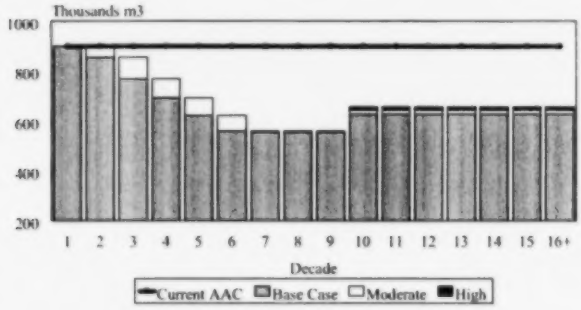

Figure 6.5 Commercial thinning and fertilization - Kootenay Lake TSA

Table 6.4 Harvest schedule - commercial thinning and fertilization (m^3)

Decade	Base Case	Moderate Response[1] (20%)		High Response (35%)	
		Change in Harvest Level[2]	(%)	Change in Harvest Level	(%)
1	9,000,000	0	0	0	0
2	8,550,000	450,000	5	450,000	5
3	7,695,000	855,000	11	855,000	11
4	6,925,000	770,000	11	770,000	11
5	6,230,000	695,000	11	695,000	11
6	5,600,000	630,000	11	630,000	11
7	5,560,000	40,000	1	40,000	1
8	5,560,000	40,000	1	40,000	1
9	5,560,000	40,000	1	40,000	1
long-term	6,280,000[3]	160,000	3	280,000	4

[1] Response is net increase in yield curve accumulated volume.
[2] Change values are total from base case, not incremental as in the Figure above.
[3] The annual long term harvest is 628,000m^3
The full treatment budget of 300 ha per year is used every year in all three response scenarios.

Significant short term (five to 11 %) and long term (three to four percent) benefits are demonstrated.

6.4 Analysis - Accelerated Green-up

As the target Douglas-fir mixes are well distributed among management zones, and since forest cover constraints are controlled through green-up at the zone level, we model green-up improvements across all zones.

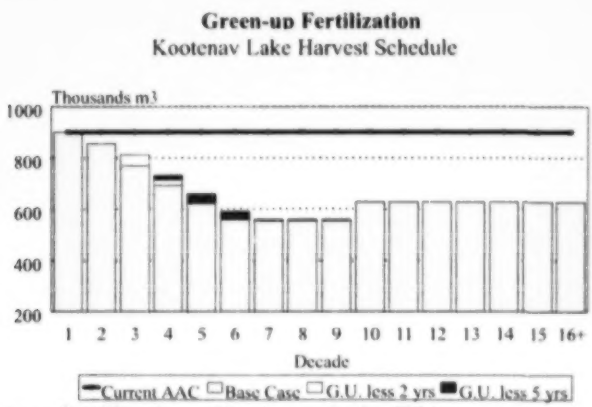

Figure 6.6 Green-up fertilization - Kootenay Lake TSA

Table 6.5 Harvest schedule - green-up fertilization (m^3)

Decade	Base Case	Green-up less 2 years		Green-up less 5 years	
		Change in Harvest Level [1]	(%)	Change in Harvest Level	(%)
1	9,000,000	0	0	0	0
2	8,550,000	0	0	0	0
3	7,695,000	425,000	6	425,000	6
4	6,925,000	220,600	3	385,000	6
5	6,230,000	60,000	1	350,000	6
6	5,600,000	0	0	320,000	6
7	5,560,000	0	0	40,000	1
8	5,560,000	0	0	40,000	1
9	5,560,000	0	0	40,000	1
long-term	6,280,000[2]	0	0	0	0

[1] Change values are total from base case, not incremental as in the Figure above.
[2] The annual long term harvest is 628,000m^3

Green-up has some short term benefit in cushioning the harvest fall down. Analysis showed some long term climb in available volume, however it was not enough to significantly impact the harvest level.

6.5 Alternate Analysis using TASS Yields

Yield Prediction

TASS yields for various silviculture treatment regimes were built. Inputs to TASS are provided in Table 6.6. Site index values are area weighted averages for contributing TSR analysis units.

Table 6.6 Commercial thinning and fertilizing regimes for TASS curves

Site Class, Site Index	Initial Density	Juvenile Space	First Fertilization	Second Fertilization	Post Commercial Thin Target	Third Fertilization
Managed Stands						
G,M,P site index 19.4	5000 sph	1200 sph @ 3.1m*	10 yrs.	20 yrs.	350 sph @ 70 yrs.	80 yrs.
G,M site index 21.1	5000 sph	1200 sph @ 3.1m	10 yrs.	20 yrs.	350 sph @ 70 yrs.	80 yrs.
P site index 16.8	5000 sph	1200 sph @ 3.1m	10 yrs.	20 yrs.	350 sph @ 70 yrs.	80 yrs.
Natural Stands						
G,M,P site index 19.4	9000 sph	1200 sph @ 3.1m	10 yrs.	20 yrs.	350 sph @ 80 yrs.	90 yrs.
G,M site index 21.1	9000 sph	1200 sph @ 3.1m	10 yrs.	20 yrs.	350 sph @ 80 yrs.	90 yrs.
P site index 16.8	9000 sph	1200 sph @ 3.1m	10 yrs.	20 yrs.	350 sph @ 80 yrs.	90 yrs.

* All juvenile spacing is previous to any fertilizaton

TASS curves were subjected to standard operational adjustment factors (OAFs) of 15 % and five percent.

Establishing a Base Case

In order to isolate the effects of commercial thinning and fertilizing TASS control (no treatment) yield curves were used for treatment candidates to build a base case. This results in higher initial inventory volumes in the natural stands candidates. It could be argued that the standard OAFs of 15 % and five percent are insufficient, but no data is available upon which to base their replacement. As a result the TASS base case shows significantly higher harvest levels throughout the analysis period. Once again, this is acceptable as the benefits to thinning and fertilizing are best considered as marginal improvements, not absolute values.

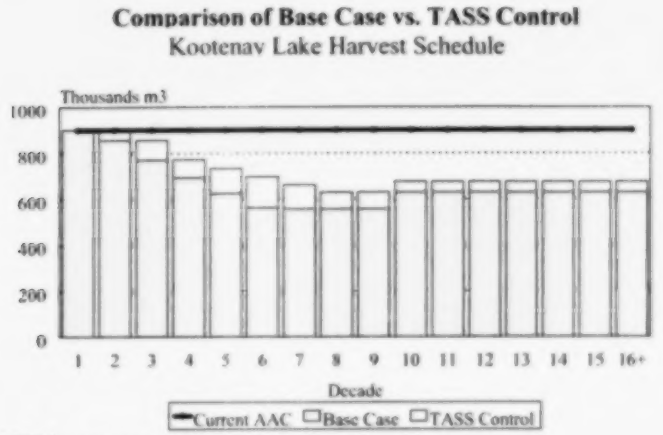

Figure 6.7 TASS base case

Analysis - Commercial Thinning and Fertilizing

The same commercial thinning methodology as modelled in the preceding analyses is used here. The yields are TASS output from incremental regimes as described in Table 6.6. Once again a 300 ha per year limit on thinning was imposed.

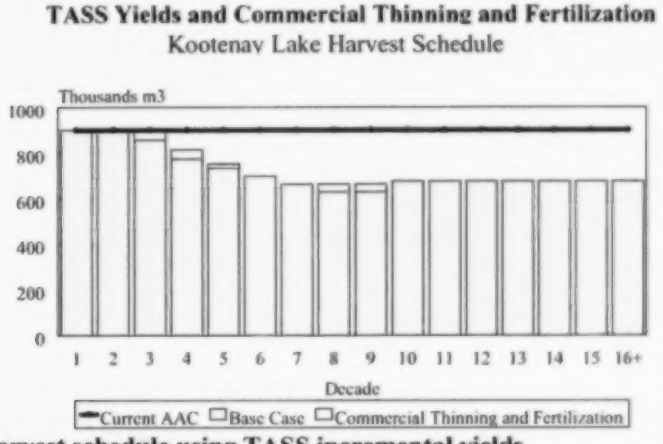

Figure 6.8 Harvest schedule using TASS incremental yields

Table 6.7 Harvest Schedule TASS Yields (m^3)

Decade	TASS Base	Change in Harvest Level [1]	Change (%)
1	9,000,000	0	0
2	9,000,000	0	0
3	9,000,000	450,000	5
4	8,120,000	400,000	5
5	7,510,000	180,000	2
6	6,960,000	0	0
7	6,610,000	0	0
8	6,610,000	330,000	5
9	6,610,000	330,000	5
long-term	6,750,000[2]	0	0

[1] Change values are total from base case, not incremental as in the Figure above.
[2] The annual long term harvest is 675,000m^3

Our TASS analysis demonstrates five percent increases in the short and mid terms, no improvement in the long term. This is approximately in line with the low response scenario described in Figure 6.3 and Table 6.2.

Benefits appear to be more conservative than with our subjectively modified curves due to the nature of the TASS curves. The forest level model accumulates commercial thinning volumes based on the difference between the pre- and post thinning yield curves. In the case of the subjectively modified curves we have direct control of the volume removed. The difference in volumes between TASS control and TASS treatment curves is smaller and this produces lower commercial thinning volumes. The result is less positive impact at the forest level. As the thinned stands age, TASS is generally reporting parallel volume curves and the long term impact is low.

6.6 A Management Scenario for The Kootenay Lake TSA

After reviewing results of the above analyses, a TSA management scenario representative of a reasonable opportunity to reduce the impact of falling harvest levels was chosen.

Regime Summary

- Commercial thinning and fertilizing:
  Five percent increase in accumulated volume,
  treatment limit of 300 ha per year.
- General fertilization program:
  managed stands which are not thinned,
  15 % increase in accumulated volume.
- Early fertilizing reduces green-up by two years.

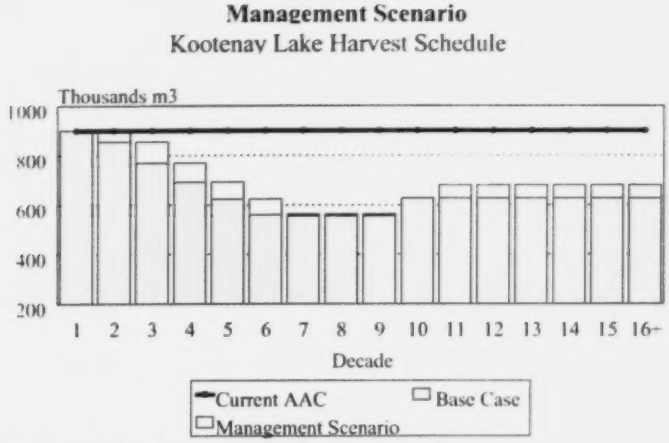

Figure 6.9 Harvest schedule - management scenario

Table 6.8 Harvest schedule - management scenario (m^3)

Decade	Base Case	Change in Harvest Level [1]	Change (%)
1	9,000,000	0	0
2	8,550,000	450,000	5
3	7,695,000	850,000	11
4	6,925,000	770,000	11
5	6,230,000	695,000	11
6	5,600,000	630,000	11
7	5,560,000	70,000	1
8	5,560,000	70,000	1
9	5,560,000	70,000	1
10	6,280,000	0	0
long-term	6,790,000[2]	51,000	8

[1] Change values are total from base case, not incremental as in the Figure above.
[2] The annual long term harvest is 679,000m^3

Significant short term gains (five to 11 %) and smaller long term gains (eight percent) are demonstrated.

6.7 Discussion

The TSR definitions of analysis units are a serious hindrance to modelling commercial thinning and fertilizing in the Kootenay Lake TSA. Analysis units are meant to facilitate modelling by aggregating together stands which are biologically similar in terms of growth pattern and regeneration practices. Separation of growth patterns and productivity are important to maintain resolution in analysis. The TSR put more emphasis on management of visual quality, wildlife habitat etc. than on silviculture management regime. For example analysis unit 1 is Douglas-fir, larch, pine, cedar, hemlock, and balsam leading stands, good, medium, and poor site quality in the deer/elk winter range management

zone. This masks biological response to commercial thinning and fertilizing. Good sites may green-up or reach maturity sooner and alleviate constraints earlier than they would when bundled in a homogenized lower average site productivity analysis unit as currently included in the MoF base case analysis for this unit.

The TSR did not use managed stand yields. For this reason the benefits that would accrue from basic silviculture were not reflected in the analysis. For this report, a new base case using managed stand yields was created to ensure separation of benefits from treatments from benefits due to basic silviculture.

Based on our analyses, commercial thinning, without fertilization, demonstrates significant benefits in the short term (five to 11 %). This reflects the degree to which forest cover constraints are limiting short term harvests. Commercial thinning alone demonstrated little or no long term harvest level benefit.

A general fertilization program (no commercial thinning) demonstrates significant short term gains (six to 12 %) independent of stand response assumption. Only moderate and high response assumptions demonstrated any long term gains (six and 12 % respectively). Harvest prospects improve in the short term through the 'allowable cut effect' of harvesting old growth faster as future requirements are filled by higher volume managed stands.

Early fertilization for accelerated green-up provides a small short term benefit.

A combined commercial thinning and fertilization regime resulted in 11 % short term gains and increases in harvest levels in the long term ranging from three to eight percent. Short term benefits reflect the degree to which forest cover constraints are limiting short term harvests. The availability of older existing stands allows volume increases in managed stands to be translated to short term harvest increases.

An analysis using TASS thinning and fertilizing yields was produced for comparison. The TASS control yields were significantly higher than the VDYP natural stand curves they replaced. This was not the case for managed stands. The operational adjustment factors used for managed stand yield curves may be inappropriate, but no practical options are available. Despite these issues, the TASS curves are acceptable for a base case as the benefits to commercial thinning and fertilization are best considered as marginal improvements, not absolute values.

The TASS analysis indicates lower benefit in the long run. The short term increases in harvest are most similar to the low response to commercial thinning only analysis run.

The difference in benefits using TASS curves is associated with lower captured volumes from commercial thinning. Lack of comfort with the TASS analysis resulted in it carrying less weight in selection of a management scenario for the TSA. Chosen were yields reflecting a moderate response to commercial thinning (five percent accumulated volume

increases), green-up accelerated by two years, and a general fertilization program in managed stands resulting in 15 % accumulated volume increases. Benefits in terms of increased harvest volume are five to 11 % per decade in the short term and eight percent in the long term.

7.0 DISCUSSION

Our analyses indicate significant harvest level benefits from commercial thinning and fertilization. They also make it clear that each TSA has its own particular situation, its own best strategy, and its own level of anticipated benefits.

This report describes the results from two timber supply areas. These results can not be extrapolated to other TSAs or rolled-up to provincial estimates. One can however, look for similar forest conditions in other TSAs and draw inferences. The methodology demonstrated here can be used to evaluate possibilities in other TSAs. In fact much can still be done to improve this methodology in the context of a detailed TSA specific study. Examples of improvements to the methodology follow:

- Using the TSA forest and silviculture inventory data sets, specifically identify stands which are candidates for treatment or which have already had treatment;
- Obtain additional local input into specific silvicultural regimes which may improve resolution;
- Broaden the scope of treatments;
- Independent of stand yield modelling system, build a unified set of yields which reflect the current research and expert opinion available, and
- Redefine the base case analysis (analysis units, management scenarios) to better model intensive silviculture.

Critical to increasing the confidence one can have in the results of projects of this type is improving the data and tools available for stand modelling. Although forest level benefits can be demonstrated at all levels of stand yield response, the magnitude of benefits is sensitive to the stand yields. There remains a need for further investigation of growth and yield under commercial thinning and fertilization management regimes.

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APPENDIX I

TSA TEST CASE SELECTION

Introduction

This Appendix provides a review of Timber Supply Review documents which was undertaken to identify candidate TSAs for analysis of the benefits to fertilization and commercial thinning.

The review included the TSR reports and the AAC Rationale reports for all TSAs.

Provided below is a cursory look at each TSA with regard to fertilization and commercial thinning. It should be seen as a general evaluation of TSA suitability for analysis of implications of these intensive silviculture activities. Once candidates were selected, further review was undertaken including discussions with Regional and District staff.

Timber Supply Review

Incremental silviculture was generally not considered in the TSR, and practically none of the TSRs provide any information at all on treatment candidates. Neither do the TSRs provide species/site/age breakdowns to specifically evaluate the availability of candidates for treatment.

In several TSAs the short term sensitivity to changes in green-up and/or changes in forest cover constraints is masked by the tendency to cap harvest flow at the current AAC level until it needs to fall.

The following table presents a summary of review results. TSAs are roughly ranked by preliminary candidacy for analysis. Other than three general and subjective categories of suitability TSAs are ranked alphabetically.

Initial Ranking for Suitability for Analysis

TSA	Priority for analysis	Comment
Arrowsmith	High	MoF investigating commercial thinning and fertilization.
Cranbrook	High	Significant benefits possible.
Fraser	High	Fertilization used, tight timber supply.
Kalum	High	Commercial thinning is base case, probable benefits.
Strathcona	High	Benefits likely.
Sunshine Coast	High	Potential benefits, large area candidate for commercial thinning.
Williams Lake	High	Age gap problem.
Golden	Moderate	No activity, no market for commercial thinning products.
Invermere	Moderate	Age class problem, likely benefits.
Kamloops	Moderate	No significant history of activity.
Kingcome	Moderate	No history of activity but a real need to do something.
Kootenay Lake	Moderate	Possible benefits but lacks candidate stands.
Lakes	Moderate	Potential benefits but strong timber supply situation.
Mid Coast	Moderate	Opportunities biologically but not economically.
Okanagan	Moderate	Possible gains but few candidates.
Quesnel	Moderate	Do fertilize, strong timber supply situation.
Soo	Moderate	No green-up benefits likely, timber supply needs help.
Boundary	Moderate	No age class problem, commercial thinning and fertilization currently practiced.
Robson Valley	Moderate	Possible gains, lack of candidates.
100 Mile House	Low	Significant gains unlikely.
Arrow	Low	Limited candidates.
Bulkley	Low	Strong timber supply situation, no age gaps.
Cassiar	Low	Remote TSA, no track record.
Dawson Creek	Low	Remote TSA, strong timber supply situation.
Fort Nelson	Low	Remote TSA.
Fort St. John	Low	Strong timber supply situation.
Nass	Low	No activity or likely benefits.
Kispiox	Low	Strong timber supply situation.
Lillooet	Low	No history of activity, limited benefits.
Mackenzie	Low	No activity, no opportunity for timber supply benefits.
Merritt	Low	Strong timber supply and age class distribution.
Morice	Low	Strong timber supply situation.
North Coast	Low	No activity, no opportunity for timber supply benefits.
Prince George	Low	Strong timber supply situation and no track record.
Queen Charlotte	Low	Lack of candidates.
Revelstoke	Low	Progressive liquidation of old growth.

Our mandate was to undertake analysis on one coastal and one interior TSA. Arrowsmith was chosen for the coastal TSA. Cranbrook, Williams Lake, Golden, Invermere and Kootenay Lake were looked at more closely before Kootenay Lake was chosen for the interior analysis.

Following are individual TSA discussions upon which the table is based.

100 Mile House

TSR:

- Age class distribution: abundance of 100-140 and little in 30-70 years.
- Current harvest level is below the long term level and is sustainable for 200 years at which time it can rise.
- 31 % of land base identified as suitable for partial cuts to meet wildlife and biodiversity requirements. (special management zone with extended green-ups is 11 %).
- Not sensitive to green-up, minimum harvest age as adjacency and timber availability are not limiting.

AAC Rationale:

- There is no commercial thinning program and it is not required to fill age class gaps.
- Fertilization is not mentioned.

Evaluation:
Low priority for further analysis due to low possible gains. Commercial thinning is a possible practice in special management areas.

Arrow

TSR:

- Age class distribution: no holes, lots of mature to overmature.
- 42 % of land base in special management zones but all forest cover constraints are 3 metre and 4-pass.
- Current harvest maintained for seven decades.
- Noted significant uncertainty in green-up and cover constraints to which the analysis was very sensitive.
- Sensitive also to minimum harvest ages.
- Sensitivities artificially show as mid term due to harvest level cap at current AAC.
- In Arrow TSA, harvest scheduling is a challenge. This is a good situation for possible increases in harvest flow due to fertilization (shortening green-up).

AAC Rationale:

- 10 % of cut comes from partial harvests.
- Partial cuts (including commercial thinning) could address timber supply but opportunities are limited by terrain, species suitability and root rot.

Evaluation:
Possible benefits but limited candidates. Not a candidate for analysis.

Arrowsmith

TSR:

- Age class distribution depends on location:
  East side of island, immature forest with few stands 10-30
  West side, overmature and 0-50 with nothing in the middle.
- 34 % of land base managed for visual quality.
- Immediate reduction of cut by two percent and three 10 % step downs.
- Reverting Timber Licences swell the ranks of the disturbance class and limit harvest until they reach green-up.
- Sensitive in short term to green-up, and forest cover requirements.
- Commercial thinning and fertilization are practiced but not modelled for the TSR report (although work has been done subsequently).
- Douglas-Fir is the commercial thinning candidate.

AAC Rationale:

- There is no AAC Rationale Report available at time of writing.

Evaluation:
All the right conditions for both fertilization and commercial thinning. Candidate for analysis.

Boundary

TSR:

- Unbalanced age class distribution with little < 40 years and much 61-80 years.
- 20 % of the land base has five pass and nine metre green-up (for wildlife).
- Short term timber supply is sensitive to tighter forest cover constraints, and to a lesser degree green-up periods.
- Current harvest level maintained for 8 decades.

AAC Rationale:

- Age class distribution not limiting.
- Fertilization used in the District resulting in some volume increases and accelerated green-up. Not considered in AAC due to small area and small effect.
- Commercial thinning identified as opportunity to offset harvest reductions.
- 17 % of cut is currently intermediate cuts of some kind.
- Opportunity to expand this due to availability of candidates.
- Because don't see age class structure as a problem, don't see big possibilities in harvest flow improvements. It would be interesting to check this out.

Evaluation:
Moderate priority candidate. Nelson region is currently evaluating this TSA.

Bulkley

TSR:

- Well balanced age class distribution, with 50 % over 200 years of age.
- 25% has special cover constraints.
- Maintain current cut for 20 years.
- Insensitive to changes in forest cover, green-up and minimum harvest age.

AAC Rationale:

- Intensive silviculture currently includes commercial thinning. There may be some timing benefits but the age class structure provides no opportunity.
- Fertilization not mentioned.

Evaluation:
Strong timber supply situation. Low priority candidate.

Cassiar

TSR:

- Fairly balanced age class structure.
- Capable of substantial increase in AAC (basically even-flow at about 850,000).
- Theoretically sensitive to green-up but so undercut that it is irrelevant.

AAC Rationale:

- There is a plan for some fertilization in concert with juvenile spacing, but no track record.

Evaluation:
Low priority candidate.

Cranbrook

TSR:

- Harvest level 10 % decrease and declining.
- Age class distribution heavy to 50-100 years, little old growth.
- Given age class distribution, it is likely that commercial thinning would ease timber supply.
- 34 % of net land base has six or nine metre green-ups for VQO, watershed and riparian.
- Midterm only - sensitive to lower minimum harvest ages.
- Sensitive in short and mid term to both green-up and forest cover.
- Sensitive to four and five pass system but no test of relaxed adjacency such as by partial cuts.
- Incremental silviculture not mentioned.

AAC Rationale:

- District fertilizes over 500 ha per year and anticipate volume gains of 15 m^3/ha for each treatment. This total implication is 7,500 m^3 of immature growth per year.
- Fertilizing was not reflected in base case but represents an upward pressure which the Chief Forester feels will not be in the short term.
- Approximately 40 % of forests in TSA are 30-80 years old and possible candidates for commercial thinning.
- Little commercial thinning has taken place and further study is required before the potential impacts can be considered in an AAC determination.

Evaluation:
Commercial thinning and fertilization have the potential of making significant improvements in timber supply analysis. Cranbrook is a candidate. Nelson Region is currently evaluating this TSA for commercial thinning opportunities.

Dawson Creek

TSR:

- No age class gaps, large area between 90 and 140 years of age.
- 25 % managed for VQOs (5 metre green-up and low maximum denudation %'s).
- Even-flow timber supply above existing level due to abundance of mature stands.
- Not very sensitive to changes in forest cover and green-up.

AAC Rationale:

- There is no AAC Rationale Report available at time of writing.

Evaluation:
Likely no commercial thinning or fertilization program and timber supply benefits unlikely. A low priority candidate for further analysis.

Fort Nelson

TSR:

- The report that is available is pre-TSR program.
- There is no age class or sensitivity data.
- No fertilization or commercial thinning is mentioned. The incremental silviculture seems to be limited to reforestation and rehabilitation.

AAC Rationale:

- There is no AAC Rationale Report available at time of writing.

Evaluation:
Remote TSA with a strong timber supply situation. Low priority candidate.

Fort St. John

TSR:

- Age class distribution: 40-160 with no gaps, low in <40.
- Separate Deciduous AAC.
- Conifer AAC can increase by 95 %.
- Non-declining harvest flow masks any sensitivities.

AAC Rationale:

- There is no AAC Rationale Report available at time of writing.

Evaluation:
Strong timber supply situation and current undercut preclude timber supply flow improvements from fertilization or commercial thinning. Remote TSA. Low priority candidate.

Fraser

TSA:

- Well balanced age class except an extra bulge in the 20-40 year range.
- Immediate 12 % reduction in current cut, and further steps down.
- four pass, 3 metre green-up in IRM.
- VQO- 5m (26 % of the net land base, more than half of that highly sensitive.)
- Moderately sensitive to forest cover and green-up in the short term.
- Visual quality constraints play a big part in reducing the cut.

AAC Rationale:

- Existing old growth is on poorer sites. The large area of 20-40 years is on better sites but not available for 40-50 years.
- Fertilization is current procedure for all poor and half the medium sites and the TSR reflects a four-percent increase in volumes at harvest age.
- Commercial thinning is identified as a potential influence on timber supply but there has been little performance to date.

Evaluation:
Commercial thinning (or any partial harvest) could be effective in addressing visual concerns. Fertilization to enhance green-up offers possibilities. Candidate.

Golden

TSR:

- Good area distribution by age class.
- 7 % initial drop in harvest level and step-downs after that.
- Moderately sensitive to forest cover and green-up.

AAC Rationale:

- Age class structure not limiting in the determination of an AAC.
- Incremental silviculture limited to ICH and MS near Golden due to economics.
- No local mills to use products of commercial thinning (pulpwood, fence posts) and there is no track record of commercial thinning.

Evaluation:
Some potential benefits but not a strong candidate.

Invermere

TSR:

- Age class distribution: a lack of 20-50 year old stands which necessitates a decline in harvest as soon as 10 years.
- 13 % immediate reduction, 12 % for 5 decades after that.
- Current cut far above sustainable level, forest cover constraints are limiting.
- Short term sensitivity to forest cover constraints, especially ungulate winter. Minimum harvest ages and green-up are less sensitive.
- Sensitive to overall removal of forest cover constraints.

AAC Rationale:

- 10 % reduction.
- There is a significant fertilization program planned.
- Increased tree growth through intensive silviculture likely to have some short term effect. Chief Forester presumed a small effect and considered a small upward pressure.
- Commercial thinning opportunities exist and there is an age class gap to be addressed.

Evaluation:
Age class distribution is a problem. Possible candidate for analysis.

Kalum South

TSR:

- Timber supply situation is a 3 % harvest decrease and declining.
- Typical bulges in 0-20 and 300+ ages, second growth available in 70 years.
- Juvenile spacing, commercial thinning and pruning are practiced.
- Analysis reflects 25 % of good sites commercially thinned (TASS yields).
- Analysis shows commercial thinning contributes 3 % of cut over 20 years.
- District plans to thin 75 % of good sites.
- 31 % net land base is VQO and analysis is sensitive.
- Sensitive to minimum harvest ages. Sensitive to green-up.
- Short term supplied effected by commercial thinning but not long term.

AAC Rationale:

- District currently developing a 20 year plan for commercial thinning.
- Candidates: site index (50 yrs.) > 26, some medium (site index 18-26).
- 5,000 ha of candidates exist, plus large 20 year old stands will ensure lots of opportunities.
- Benefits seen to be harvest flexibility, not total volume.
- Alternatives to clearcutting for visual and adjacency discussed but no information to estimate impacts.

Evaluation:
Commercial thinning is base case in the Kalum TSA and requires further analysis

Kamloops

TSR:
- Age class distribution: shortage of area in 40-50 year age class.
- Maintain current cut for 20 years followed by 9 % per decade steps down for several decades.
- The visual quality zone (22 % of land base) with very restrictive cover constraints (10 % max. depletion < six metre) is initially locked up.
- Sensitive to minimum harvest ages, green-up, VQO cover requirements.

AAC Rationale:
- Partial harvests are being used to address visual and wildlife concerns.
- No commercial thinning program and no need to fill in gaps. Impacts are limited to value and timing and no long term volume benefit.
- Annual fertilization program of 165 ha in lodgepole pine. No short term effect, small areas, no AAC impact.

Evaluation:
Sensitivity to minimum harvest ages suggests that the age gap at 40-50 years could be filled with partial harvests or decreased with support from fertilization. Possible benefits especially VQO management regime (possible candidate).

Kingcome

TSR:
- Uneven age class distribution, little between 110 and 210 years, bulges at 300 yrs. + and < 30 yrs.
- Immediate 35 % decrease in cut level.
- Heavily effected by visual quality (43 % of land base) and adjacency forest cover constraints.
- Little of the mature timber is available in the short term.
- VQO-R and VQO-M are currently double the maximum disturbance levels.
- Very sensitive to green-up.
- Moderately sensitive to regeneration delay, visual quality, forest cover constraints.

AAC Rationale:
- Steep terrain and windthrow limit partial harvest opportunities.
- Spacing and fertilizing identified as potentially offsetting timber supply shortages.
- Little fertilization has been done and no impact was assumed for AAC.

- 17 % of land base between 30 and 80 and therefore candidate for commercial thinning but there is no history of its use.

Evaluation:
Real need to implement incremental silviculture, potential candidate.

Kispiox TSA

TSR:
- Predominance of older age classes.
- Base case holds the current harvest level for four decades.
- Insensitive in short term to green-up and adjacency due to the capped harvest flow and significant timber availability.

AAC Rationale:
- Not available at time of writing.

Evaluation:
Few benefits likely, low priority for analysis.

Kootenay Lake

TSR:
- Fairly well balanced age class structure.
- Intense forest cover constraints including: 45 % of land base in watershed zones with extended green-up ages; 25 % of land base in VQO zones with both extended green-up ages and lower maximum disturbance.
- 11 % drop in cut level and 10 % drops thereafter.
- First four decades forest cover guidelines limiting.
- Sensitive in short term to tighter constraints defined by forest cover ages. Less sensitive to relaxing them. Same pattern for minimum harvest age.
- No sensitivity to relax both undertaken by TSR.
- More sensitive to relaxing forest cover percentages.
- Suggests silviculture practices to shorten green-up for short term benefit (no such program in place yet).

AAC Rationale:
- 22 % drop in first decade.
- Juvenile spacing with fertilization is recognized as capable of relieving the forest cover constraints limiting harvest in the first few decades.
- Fertilization in trial stage only.
- No performance in commercial thinning, few candidates due to accessibility and root rot.
- Four pass adjacency drove down AAC.

Evaluation:
Complicated one for intuitive analysis of benefits. Real possibility of benefits but some doubt in AAC rationale as to candidate availability. Possible candidate.

Lakes

TSR:
- The age class distribution has gaps in the 30-40 and 90-100 year ranges and a preponderance of 120-170 years old stands.
- Maintain cut for seven decades.
- Sensitive to green-up and minimum harvest ages, and VQO cover constraints.

AAC Rationale:
- Little fertilization going on.
- Little commercial thinning has been done but there are plenty of 40-80 year old candidate stands.

Evaluation:
Possible candidate due to age class gaps but strong timber supply situation.

Lillooet

TSR:
- Current harvest can be maintained for 30 years, declining thereafter. Insensitive to imposition of a four pass harvesting system.
- Age class distribution is heavy to older but fairly well balanced except under 60 years.
- Current harvest sustainable for three decades and steps down thereafter.
- Although sensitive in mid term to minimum harvest age, forest cover constraints, and green-up these represent noise within a strong old growth liquidation trend.
- Intensive silviculture not mentioned.

AAC Rationale:
- No significant history of commercial thinning or fertilization in the Lillooet.

Evaluation:
Low priority candidate for analysis.

Mackenzie

TSR:

- No significant gaps in age class structure with a large portion over 200 years.
- 2.5 metre green-up, 33 % maximum disturbance.
- Maintain cut for 30 years.
- Mid term and long term sensitive to minimum harvest ages.
- Shortage of second growth in decades four through 6 could be addressed through partial cuts.
- Not sensitive to changes in forest cover and green-up.

AAC Rationale:

- No incremental silviculture practiced.

Evaluation:
Low priority candidate.

Merritt

TSR:

- Age class distribution: lots of old with no significant gaps.
- FCC not too onerous, 13 % of land base with tough disturbance criteria.
- VQO (10 %) maximum 10 % < six metres.
- Ungulate (3 %) maximum 20 % < three metres.
- Initial harvest maintained for 110 years due to abundance of mature.
- Insensitive to green-up and forest cover in short term due to flat line of harvest level at the current AAC (sensitive in mid term).

AAC Rationale:

- Increase in cut level.
- FRBC projects expected to increase fertilization, this was considered a small upward pressure.
- There is no commercial thinning track record in pine in this TSA, probably no volume gains, and no age class gap that required filling.

Evaluation:
Strong timber supply situation and age class distribution. Low priority candidate.

Mid Coast

TSR:

- Age class distribution: preponderance of < 50 years and > 200 years.
- three pass three metre green-up.
- Approx. 16 % of net land base in VQOs.
- Current harvest rate (excluding partition of problem forest types) maintained for one decade and steps down for six decades.
- Sensitive to minimum harvest age and less so to green-up and relaxation of VQOs.

AAC Rationale:

- The age class structure is limiting in that the existing old growth needs to be rationed until the young stands are available.

Evaluation:
Partial harvests could ameliorate the age class situation as well as address forest cover constraints. As perhaps could fertilizing if it could be shown to increase piece size and decrease minimum harvest ages.
High transportation costs of thinning products and currently no large supply of candidates.
Fertilizing is an option anywhere the forest cover constraints result in green-up sensitivity.
Possible candidate.

Morice

TSR:

- A lack of 30-60 year old stands, otherwise a good distribution by age class.
- Maintain current cut for 90 years.
- Mid term sensitivity (cut level capped in short term) to minimum harvest ages, green-up and forest cover constraints.

AAC Rationale:

- Not available at time of writing.

Evaluation:
Strong timber supply situation. Low priority candidate for analysis.

Nass

TSR:

- Age class distribution, very heavily weighted to 141+.
- Current cut for one decade and steps down thereafter.
- Fibre flow driven by the high current cut and a much lower sustainable cut and the progressive step down to the latter.
- Not green-up or adjacency driven, but second growth availability is important.
- Sensitive to second growth minimum harvest age.
- Insensitive to green-up.

AAC Rationale:

- 8 % immediate reduction.
- No commercial thinning activity or plans, age composition of the forest precludes and short term fibre flow advantage.

Evaluation:
Low priority for analysis.

North Coast

TSR:

- Old forest (95 % > 140 years).
- Current harvest level maintained for 60 years.
- Due to harvest level cap, sensitive in mid term only to minimum harvest ages.
- Largely insensitive to green-up or forest cover changes.

AAC Rationale:

- Age class not limiting to analysis.
- No commercial thinning is practiced.

Evaluation:
Low priority for analysis.

Okanagan

TSR:

- Current age class distribution is balanced except for a shortage of 40 and 50 year old stands.
- 41 % of the TSA is designated for special management with strict disturbance constraints.
- Green-up of 6 metres on 83 % of land base; this is more severe than most.
- Current harvest for 20 years followed by 20 % step down over 20 years.
- Sensitive to minimum harvest age, green-up, adjacency guidelines.
- Incremental silviculture not addressed.

AAC Rationale:

- Limited commercial thinning practiced.
- Candidates are limited and root rot is a contraindication.
- Visually sensitive areas could contribute more using partial cuts.

Evaluation:
Forest structure and sensitivity analyses suggest possible gains from fertilization and commercial thinning but the MoF discounts the existence of candidates. A possible candidate for analysis.

Prince George

TSR:

- Well balanced age class distribution allows harvesting flexibility.
- Harvest sustainable 6 % above current AAC indefinitely, with room to increase in short term without puncturing base case even flow.
- Forest cover constraints are not restricting, therefore not particularly sensitive to green-up or adjacency.

AAC Rationale:

- 3 % increase in cut.
- Commercial thinning and fertilization are practiced only rarely in the TSA. Possible timber supply benefits are precluded in that the analysis indicates to opportunities to fill age class gaps and adjacency is not limiting.

Evaluation:
Strong timber supply situation and no track record. Low priority for further analysis.

Queen Charlottes

TSR:
- Unbalanced age class distribution, heavy to 0-50 and 290+.
- 14 % immediate reduction, and 12 % for six decades.
- Forest cover for biodiversity and scenic values contribute to this.
- Liquidation of an old, mostly poor site quality, forest.
- Insensitive to decreasing minimum harvest age.
- Small improvements from green-up and forest cover constraints being loosened.

AAC Rationale:
- 8 % reduction.
- Age class unbalance contributes greatly to the long decline.
- Commercial thinning limited by the absence of suitable stands on accessible terrain.

Evaluation:
Low priority for analysis.

Quesnel

TSR:
- Age distribution: concentration in 60-120 year range.
- Maintain current harvest level for 70 years.
- 23 % of the land base has some extended green-up constraint which is basically 4-pass.
- Sensitive to forest cover and other changes in mid term only.

AAC Rationale:
- 23 % of stands may be suitable for commercial thinning (30-80 years old).
- 7 % if pine are only suitable for the ages 30-50.
- No commercial thinning currently practiced.
- In the past 10 years 3,300 ha have been fertilized.
- Fertilization seen as a boost to long term levels as volume is added to regenerated stands and is not regarded as green-up boost (probably due to particular application regimen).

Evaluation:
Possible short term benefits to fertilization hidden in even-flow initial harvest schedule. No age gaps to fill. Possible candidate with fertilization track record.

Revelstoke

TSR:
- Age class distribution: heavy to 0-20, 220, 300+, but significant 80-120.
- Long step down to LRSY due to surplus old growth.
- Initial harvest 6 % decrease and falling.
- Some short term flexibility with decreasing minimum harvest ages of second growth.
- Forest cover and green-up sensitivities show short and mid term flexibility.
- Incremental silviculture not mentioned.

AAC Rationale:
- Initial harvest 14 % decrease and falling.
- Commercial thinning seen as short term flexibility item with no long term impact and potential treatment areas are not common.
- Fertilization is seen to decrease green-up by three to four years and provide further short term flexibility but fertilization not current practice.

Evaluation:
Old growth is sustaining the current cut. Revelstoke is a low priority candidate for analysis.

Robson Valley

TSR:
- 70 % of timber harvesting land base is at least 100 years old.
- 20 % VQO zones with five metre green-up and low maximum disturbance rates.
- An additional 5 % on four pass three metre green-up.
- Current Harvest maintained for 10 years and step downs thereafter.
- Sensitive to forest cover constraints, minimum harvest ages, green-up ages and visual quality requirements.
- Incremental silviculture not addressed.

AAC Rationale:
- Age class structure not limiting.
- No fertilization activity.
- Commercial thinning limited by a lack of candidate stands.

Evaluation:
May be real gains through fertilization to address green-up and commercial thinning for visual concerns. Lack of thinning candidates.

Soo

TSR:

- Immediate reduction of 13 % to harvest level.
- Large proportion of ages < 50 years.
- Shortage of mature timber makes the analysis very sensitive to minimum harvest age.
- Insensitive to green-up as cover constraints are generally not limiting.

AAC Rationale:

- Minimum harvest age based on product, not CMAI.
- Soo has an aggressive intensive silviculture program including fertilizing 1100 ha per year but the TSR did not include the benefits.

Evaluation:
Benefits must come from getting the immature stands in a harvestable state sooner, commercial thinning or pre-harvest fertilization. Possible candidate.

Strathcona TSA

TSR:

- Timber supply situation - 12 % decrease and declining.
- Forest cover for scenic a major factor, 37 % of area is VQO.
- No abundance of old growth, delay in young forest causes mid term slump.
- Sensitive to green-up period, small increase in short term but fills in mid term slump.
- Sensitive to visual quality requirements.
- Sensitive to regenerated stand yields, fills in mid term as well as higher long term.
- Not sensitive to minimum harvest ages (in isolation).
- No discussion of incremental silviculture.

AAC Rationale:

- Directly discusses commercial thinning, spacing and fertilization.
- Cites Timberline analysis which suggests a short term increase with commercial thinning (fir and hemlock good and medium sites).
- Existing commercial thinning program, 45,000 m^3/yr.
- Acknowledges benefits of improved age class distribution, temporary supply shortages, enhanced wildlife habitat and protection of aesthetic values.
- Quote research staff as saying little increase in total stand yields over rotation, no adjustment.
- Some discussion of possibility of partial harvests ameliorating visual impacts
- Fertilization program 1000 ha/yr.
- Claims two m^3/ha per year for seven years following treatment.

- Evaluation of fertilization limited to volume gains and doesn't consider green-up.
- "...fertilization... but the associated volume gains were not reflected in the base case; this exerts upward pressure on future timber supplies and is a cause of some optimism for the medium to long term."

Evaluation:
Strathcona presents an age class structure and timber supply situation which hold promise for benefits from fertilization and commercial thinning.

Sunshine Coast

TSR:
- Age class distribution: predominantly < 100 years old with no significant gaps but not much old growth.
- Maintain current cut for one decade and step down after that.
- The lack of mature timber and management for visual quality are an important factors.
- VQOs cover 55 % of the land base (5m and low maximum denudation).
- Moderately sensitive to changes in minimum harvest ages.
- Extremely sensitive to changes in disturbance constraints and green-up ages.

AAC Rationale:
- Commercial thinning is planned by the SBFEP and some major licencees.
- There is an abundance of young stands which may be suitable.
- Inappropriate species, sites, and terrain limit opportunities.

Evaluation:
Commercial thinning to ease VQO constraints and fertilizing have real potential benefit if candidate stands exist. This TSA is a candidate for analysis.

Williams Lake

TSR:
- Young forest, 80 % < 150 yrs., with significant areas < green-up.
- Separated into main TSA and Western Supply Blocks.
- Western Supply Blocks are significantly undercut.
- Not particularly onerous green-up constraints.
- Harvest flow is current + uplift for two years, current for eight years and falling thereafter.
- Adjacency is limiting in the first few decades.
- Insensitive to decrease in minimum harvest ages.
- Insensitive in the short term to shorter green-up periods.

AAC Rationale:

- Incremental silviculture could provide an opportunity to offset any possible reductions in timber supply.
- 13 % of timber harvesting land base (all stands 30-80 years) may be suitable for commercial thinning. No present activity or strategy for implementation.
- Commercial thinning not considered in AAC determination, but could be used to fill age gaps.
- Partial harvests in special management areas could be used to soften timber supply shortages. A significant portion of the old growth exists in these zones.

Evaluation:

Commercial thinning could be used to fill a significant age class gap in 50 years. Williams lake is a candidate for analysis.